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STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Third Annual

Joint Service Pollution Prevention Conference and Exhibition

"Achieving Compliance Through Pollution Prevention"

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1998 Joint Service Pollution Prevention Conference Proceedings

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HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

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Dear Conference Attendee

Welcome to San Antonio and to the Annual Joint Service Pollution Prevention Conference and Exhibition! Because of your continued support and response, this conference continues to grow each year, resulting in an expanded agenda to meet the needs of a broader audience. This year, we have a larger number of speakers with more diversified topics than ever before, plus a wider variety of vendor/government exhibits. For the first time, we are also doing a live web broadcast of all plenary sessions.

You are joined by other service members, industry, academia, state and local government, other federal agencies, and foreign governments, along with the news media. With such a large spectrum of attendees, I look forward to a lively open forum for exchanging ideas, success stories, and new technologies related to pollution prevention implementation.

This proceeding is provided for your information and to help facilitate your attendance at the conference. If you require any additional assistance, please contact Lieutenant Colonel Gregory Seely or one of his staff through the information desk. Our goal is for you to have an enjoyable, productive, and informative stay.

Sincerely

GARY M. ERICKSON, P.E.
Director

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FORWARD

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Session I
Affirmative Procurement/Green Construction

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Sustainable "Green" Construction

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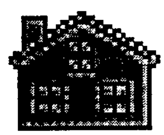

Sustainable construction encompasses people's relationships with the environment. In 1789 Thomas Jefferson said " the earth belongs to each . . . generation during its course, fully and in its own right, no generation can contract debts greater than may be paid during the course of its own existence." Jefferson clearly realized the importance of what we refer to today as "sustainable construction," but over two hundred years later, movement towards a sustainable future have only just begun. For an environment to live off its interest rather than consuming its capital, recognizing and capitalizing on the interdependence of economic and environmental resources is necessary. In order to recognize and apply this interdependency it is important to be familiar with the sustainable construction program, the constraints for its implementation and the resources available to incorporate sustainable construction into the overall construction process.

Sustainable Construction Program

Long-term economic and social benefits are derived from environmentally friendly construction practices. There are notable benefits to be gained from building "green." Sustainable buildings are enhanced by their natural environment. For example, the Green Neighborhood project at Fort Hood Army Installation, TX, integrated housing within the natural habitat. Trees and shrubs were strategically planted around houses to reduce solar gain in hot weather. Using vegetative cooling techniques cut energy bills and improved indoor and outdoor comfort for residents. Studies show that another benefit of sustainable construction is the increased efficiency of employees. The Rocky Mountain Institute reports that people working in sustainable buildings are 15 percent more productive than people working in "traditionally" constructed buildings (Browning). In a financially dependent society, increasing productivity is important to every company. This shows that "green" buildings can provide a competitive advantage.

The design, construction and maintenance of the 81 million buildings in the U.S. today have a tremendous impact on the environment and its resources. According to published reports, facilities in the United States use 17% of the total freshwater flows and 25% of harvested wood; are responsible for 50% of chlorofluorocarbon (CFC) production; use 40% of the total energy

flows; and generate 40% of landfill material from construction waste (Roodman). Sustainable construction practices often overlook the interrelationships between the building, its surroundings and its inhabitants. Sustainable building practices act upon these interrelationships in order to reasonably and efficiently use natural resources. This is done by considering the building, its surroundings, and its inhabitants in every aspect of design and construction. Smart building practices can minimize pollution and energy loss while maximizing the health, safety and comfort of the building's inhabitants. According to the Report of the National Commission on the Environment, "sustainable development does not mean leaving all of nature cordoned off and untouchable, just as it does not mean developing every acre." Responsible stewardship offers a great opportunity to create environmentally sound and efficient buildings by using an integrated approach to design. However, it is important to implement sustainable construction into the design phase of construction for it to be executed in the construction phase. Applying this early approach increases the chances and options for sustainable construction in the execution phase.

Sustainable construction must be included in all phases of a building's life. In order to increase the availability and implementation of sustainable construction practices, companies and the public can encourage architects and engineers to create more environmentally friendly building techniques. Implementing sustainable construction is a team effort that requires commitment to a "green" design from the start. This requires goals agreed upon by the architect-engineer (A/E) and the customer. Just as a football team has a common goal when entering a game, the project team must determine a common goal when entering into a contract to ensure a commitment to sustainable construction. This goal may involve appropriate sustainable construction ideas without jeopardizing budgeting considerations. In other words, finding an appropriate balance between the A/E and the customer in terms of sustainable construction parameters like cost, quality, and time. Sustainability goals may include the use of efficient resources, raw material minimization, or a process such as building siting or xeriscaping. An additional consideration may be to build facilities of long-term value while creating a healthy working environment for all that use the facility.

Constraints

Monetary and time investment, both real and perceived, can minimize the architect / engineer and customer's commitment to the implementation of sustainable construction initiatives. In terms of cost, it is important to recognize that economic and environmental realities may clash. With long term goals, proper planning, and attention to newly developed products, sustainable construction can be economically feasible. Mixing traditional regulatory policies with reinforced market incentives can also resolve the tension between economic goals and environmental realities. Environmental Executive Orders help to create markets for products. The creation of markets by the Government makes products more affordable to the public as well. Recycled office paper is the perfect example. Before the Government mandated recycled paper it was priced higher than non-recycled paper. Today, the prices are competitive. For the currently designated EPA guideline items, which include but are not limited to concrete and cement containing fly ash, recycled paper products, and insulation containing recovered materials, Federal Agencies must ensure that the products they purchase meet or exceed the EPA guideline standards. According to Executive Order #12873, concerning recycling and waste prevention, "in developing plans, drawings, work statements, specifications, or other product

descriptions, Agencies shall consider the following factors: elimination of virgin material requirements; use of recovered material; reuse of products; life cycle cost. . . . These factors should be considered in acquisition planing for all procurements and in the evaluation and award of contracts, as appropriate" (Section 401). This encourages the A/E and their customer to consider the environment in its goals from the outset of a project. The Department of Defense (DoD) requires the consideration of sustainability practices of a contractor before awarding a contract. According to Federal Acquisition Regulation (FAR) 36.601-3, for facility design contracts, the statement of work requires that the architect-engineer, in the design specifications, use the maximum practical amounts of recovered materials. The FAR continues, stressing the importance of energy conservation, pollution prevention, and waste reduction considerations. According to FAR 36.602-1, one of the evaluation parameters for construction and architect-engineer contracts is experience in sustainable practices. The importance of sustainable construction to a specific project is emphasized by how heavily it is considered in the A/E selection criteria. This is a step in the right direction in terms of DoD leadership in promoting green construction.

The cost benefits of sustainable construction are usually seen in the long term. For example, at Vandenberg AFB in California, family housing units were constructed with color coated stucco in order to avoid future painting costs and the air emission and solid waste associated with it. Another example is the use of cement roof tiles, which have a 100-year life expectancy. Although these sustainable practices increase capital costs, long-term operation and maintenance savings outweigh the short-term costs.

These examples highlight the need for life cycle cost analysis in project planning. Life cycle cost is the "amortized annual cost of a product, including capital costs, installation cost, operating costs, maintenance costs and disposal costs discounted over the lifetime of the product" (Executive Order 12873). For example, if you went to buy a new refrigerator and found one costing $600 and another costing $550, your initial reaction might be to purchase the less expensive model and save $50. By reading the EnergyGuide label, you may find that the more expensive model costs less to operate, making it less expensive in the long run. Life cycle cost analysis answers the cost benefit question based on the life of the refrigerator.

This cradle-to-grave philosophy can be a problem, however, with the current Federal budget system that separates capital costs from operation and management costs. The current system appears to reward projects that minimize capital costs, while not considering operation and maintenance costs. Studies show that, over the 30-year life cycle of an average building, three times as much money is spent on operations and maintenance as on the building's initial cost (HOK). Along with this, EPA research shows that building construction, operation, and demolition accounts for 42 percent of energy use in the U.S and 30 percent of raw material consumption. This illustrates that the design decisions and materials impact the building for its entire life cycle. The DoD is exploring ways to use creative funding for innovative "green" ideas. This involves using Life Cycle Cost Assessment in order to justify the higher initial costs with lower operation and maintenance expenses. The intent is to give designers an incentive to implement sustainable ideas into potential new facilities. It also highlights the interdependence of economic and environmental goals.

Time is also a constraining factor in sustainability implementation. Every construction project has a schedule that must be met. Including sustainable construction requires additional time for A/E selection, product and process opportunities and vender research. Sustainable

construction will not necessarily add time to the construction phase but rather the design phase. Some designers feel that sustainable construction adds time to their design practices the first time they implement it but after that it becomes much easier. In other words, sustainability initially adds time to the design process due to the lack of availability of information. As sustainable construction education grows among the engineering community, building developers, occupants and maintainers, resources will become more readily available.

Resources

A major complaint from designers, construction contractors, and customers is that there are thousands of environmentally friendly ideas available, but no one knows exactly where to find them or how to implement them. It is like the recycling bin. If it is next to the trashcan, the average consumer will probably recycle a soda can. If the recycling bin is inconvenient, the consumer may throw the can in the trash. The Air Force Center for Environmental Excellence (AFCEE) has created a guide to educate and make sustainable practices more accessible. Although this guide targets the Military Construction (MILCON) Process, the guide can be understood and implemented by a wider audience to educate everyone from top leadership to airmen on how to implement sustainability in everyday practices. The guide allows the user to find information on specific areas of construction, such as indoor air quality, waste management, or building materials. Used as a tool, the guide can also enable planners, designers, project managers, energy managers, environmental managers, A/E consultants and constructors to work on schedule and within the budget, while conserving and providing safe and healthy environments for people. Working on schedule and within a budget in a way that conserves resources clearly illustrates the interdependency of economic and environmental goals. To incorporate the entire Air Force team into the practices of sustainable construction, the guide will be available on AFCEE's website.

Figure 1: The Sustainable "Green" Construction Web Page www.afcee.brooks.af.mil

The Sustainable "Green" Construction website, as seen in figure 1, answers questions about sustainable construction, how to employ it, and examples of sustainability throughout the military. It allows the user to find sustainable construction information conveniently and discover how to go about the implementation process. The web page also offers the user easily accessible resources. For example, the Green Construction Website has a resources "toolbox" that links the user to resources they need to implement sustainable construction practices. These

resources include everything from military documents available at the base level to engineering technical letters and computer software sources. These resources allow the user to find information through the Internet without randomly searching for information on sustainable construction and thereby saving time. The U.S. Air Force Environmentally Responsible Facilities Guide along with the Green Construction website are examples of resources available in order to conveniently implement sustainable construction.

Sustainable construction is cost effective in the long-term, increasingly convenient to implement, and is gaining support in the military and in the civilian construction communities. Designers, contractors, customers and the general public can benefit from sustainable construction. Considering the entire life cycle of a building and its components, as well as the economic and environmental impact and performance, is the key to sustainable construction. The convenient availability of high quality information on and resources for sustainable construction can increase its visibility and its implementation in a variety of military and civilian contracts. It has been said that "we do not inherit the earth from our parents, we borrow it from our children." Sustainable construction is a way to move towards protecting and preserving the environment for tomorrow.

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P2 Through Adaptive Use of Historic Facilities

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ABSTRACT

The construction industry consumes a tremendous amount of our natural resources. Demolishing serviceable buildings and hauling the debris to a landfill makes no sense from the standpoint of reducing solid waste and conserving natural resources. Wastes associated with new construction (such as concrete, bricks, asphalt (rubble), particleboard, plywood, wood products, metals, plastics/polyresins, and insulation – some of which contain toxic constituents) approximately comprise of 15 to 30 percent of all wastes disposed in landfills. Furthermore, today's buildings are constructed for relatively short–term physical usefulness based on economic investment: buildings constructed today are engineered for a twenty to forty year use with limited flexibility for upgrades and improvement. Federal tax laws suggest that building incorporating new construction practices lose their economic value after 31.5 years. Surprisingly though, new building construction accounts for about 40% of the raw material (natural resources) consumption and 11% of total energy consumption each year. Ultimately, more natural resources and energy need to be reinvested into the demolition and re-construction of functional facilities. Rehabilitation, which is the process of making an efficient compatible use or adaptive re-use of a property through repair, alterations, and additions, can conserve natural resources, cultural resources, energy, and landfill space. Admittedly, adaptive re-use of a building is much more labor intensive than new construction, but much less material and energy intensive. Energy that is embodied in a building is completely sacrificed during demolition, and more energy must be incorporated into the process of demolition, debris removal and disposal. Rehabilitation or adaptive re-use of existing facilities can sustain the natural and cultural environment through the "recycling" of physical features of the structure, the supporting infrastructure, the character of our cultural past, and the energy resources that still exist in the facility.

INTRODUCTION

Throughout the United States, including military installations, an awareness has been emerging to become "green" by sustaining the natural environment through pollution prevention efforts. On military installations, these recycling efforts have been limited to activities centered around recycling household/office products, industrial metals, fluids (such as petroleum, oils, and lubricants), water, and the acquisition of products made from recycled materials. Little has been done to promote the tangible benefits of "recycling" existing facilities. Awareness alone is not

enough to achieve pollution prevention in any medium; knowledge, technology and policy are the key to forging and implementing pollution prevention initiatives. As other societies have shown, adaptive use, preservation, and rehabilitation of existing structures can be a significant means of preventing pollution, conserving natural resources and reducing energy consumption.

The culture, politics, and economics of historic preservation and adaptive reuse of facilities have long been implemented in Europe. Despite ravishing wars which all but demolished entire cities, the preservation, restoration and adaptive reuse of facilities (some dating back to the Middle Ages) are common occurrences and most of the time preferred over demolition and new construction. This preference stems from three primary factors: knowledge, available technology, and policy development. These factors espouse the economic efficiency of restoration/adaptive use over demolition and new construction, the desire to maintain socio-culture elements and the value that these structures contribute to society, and the need to preserve the environment through natural resource and energy conservation.

HISTORICAL BUILDINGS

The National Historic Preservation Act (NHPA) states that a building that is typically older than 50 years and/or meets other "historically significant" criteria must be considered and assessed when certain undertakings such as demolition, alteration, or reuse are to occur. The impact of the NHPA can be significant on military installations where 60% to 70% of the buildings are older than 50 years which is the case on Mare Island Naval Base and the Presidio in San Francisco. Many facilities have unique historical, cultural, and architectural values whereas other facilities such as war-time barracks and temporary buildings are more generic and would not be considered a cultural resource. Challenges arise when considering how best to use these historically, culturally, or architecturally significant buildings or the land on which they sit. Initial challenges may consist of seismic or structural strengthening, toxic substance removal/encapsulation (i.e. lead-based paint and friable asbestos), and infrastructure that does not meet current building codes. Frequently, these manageable challenges are transformed into political and social battles buttressed by unsubstantiated economic claims that the preservation, rehabilitation, or renovation of a historically significant building is too costly. There are economic as well as social and cultural advantages to recycling existing buildings for new uses:

- may require less consumption of natural resources
- may require less energy consumption and save energy already embodied in the existing structure
- may be more labor-intensive resulting in more jobs available for the community
- reduces the burden on landfills with construction and demolition debris
- may preserve cultural identity of community/military installation

Adaptive use of existing buildings builds upon an existing building's fabric, thereby conserving some natural resources by reducing the amount of materials that would be needed for new construction. Adaptive use also utilizes the existing physical energy embodied in the structure

thereby saving energy since little regard is given toward the energy requirements for the conversion of natural raw materials into building materials. Much of today's new construction has neither long-term economic value (it is conventional wisdom that the service life of some construction barely exceeds the mortgage or initial-lease term) nor cultural value.

The task at hand needs to be the generation and maintenance of the existing environment, both natural and man-made. The capacity to do this is contingent upon knowledge and understanding of ecological, socio-cultural, economical, and political issues which are predicated on informed decision-making, ownership of resources, and sustainable development. Due to these dynamics, both internal and external to an installation and the mission, the capability to respond to change needs to be addressed by adaptive strategies for the built-up environment. Currently, adaptive strategies exist at military installations and are functionally implemented when changes occur in productive activities, organizational structure, and installation rules/regulations; however, adaptive strategies have not necessarily been established for reuse/renovation and sustainable development. Positive and functional adaptive strategies for historic facility reuse can lead to sustainable development. Negative and dysfunctional adaptive strategies can lead to the depletion of natural, cultural, and economic resources. The creation of policies for the adaptive re-use of existing facilities (or more specifically, historic facilities) is an important means of sustainable development and pollution prevention.

KNOWLEDGE, TECHNOLOGY, POLICY

Three key factors (knowledge, science/technology, and policy structures) must be integrated and support economic efficiency, socio-cultural elements, and ecological integrity in order to achieve pollution prevention through sustainable development and the adaptive use of historic facilities. One of the keys to pollution prevention is knowledge. Knowledge is not just cerebral, but includes attitudes, beliefs, and practices. There may be a great deal of knowledge in areas such as the environment, soils, plants, animals, and human health as well as land utilization practices, hazardous waste management, and hazardous material reduction, but limited knowledge, practice and attitude of historic preservation inhibit the adaptive re-use of existing facilities. The promotion of knowledge, skill, and value of adaptive use and the assimilation of these principles into practice can lead to the success of pollution prevention in the construction realm on military installations. Rehabilitation or adaptive re-use of existing facilities can sustain the natural and cultural environment through the "recycling" of physical features of the structure.

Awareness and knowledge are key factors in forming the adaptive re-use ethic, but science and technology play an important role as well. There is a huge body of technical knowledge and products available for local/site specific adaptive use scenarios that are cost efficient, socio-culturally pleasing, and integrate existing structures and landscaping with the natural environment. Both the natural environment and the man-made environment need to work together. The land and buildings must be unified and promote contextualism, hard and soft infrastructure must meet the current requirements of the organization as well as have the flexibility and durability to endure changes, and surrounding uses must apply land-based planning and design for sustainable development. Through proper assessment, new developments

and technologies can be added to existing facilities to meet changing missions and organizational structures. A degree of flexibility built into the structure of new construction and existing facilities is the key to its future ability to accommodate changing missions and new technologies. Traditionally, historic facilities have used durable materials in construction in contrast to some new construction which has an expected service-life of twenty to forty years. Federal tax laws suggest that building incorporating new construction practices lose their economic value after 31.5 years. The value of using durable materials to create long-lasting buildings is obvious; however, even though the awareness of the value of durable construction and its emphasis exists in military regulations, the lowest cost usually takes precedence in practice. Generally, adaptive reuse is quickly dismissed as a viable option to meet new technological and space requirements. Proper economic analysis of the adaptive reuse option for historic facilities can lead to achieving the benefits of durable construction, lower costs, and sustainable development.

On the traditional scale, architects have the abilities for design and adapting existing structures to meet current needs, engineers have the abilities to develop/upgrade the needed infrastructure and technical systems, and policy planners/developers have the implementation skills. All disciplines that are involved in the adaptive use of historic properties have formal knowledge and technical skills that can contribute to policy formation, development planning and decision-making. Policy and/or regulations generally comprise organizational arrangements which refer specifically to political and economic externalities that impinge upon the land use planning and facility development at an installation.

It is important that knowledge, science, and policy about sustainable development, ecosystem dynamics, and historic resource management are used to support economic efficiency, socio-cultural elements, and ecological integrity. Buildings should be viewed as integrated systems rather than a set of independent components. Incorporating a systems engineering perspective into the designing, planning, and building/renovation stages can have significant effects on the decision-making aspects and ultimately the final outcome of the final product. Applying system engineering principles to historic preservation enables the integration of the architectural and cultural integrity of the structure with up-to-date technologies (i.e., HVAC, communication systems, lighting devices) and space requirements set by the organization while being cost effective, preventing pollution through natural and cultural resource conservation, and developing a sustainable environment.

RECYCLING

Adaptive re-use of historic facilities is an example of stewardship and promotes sustainable development and pollution prevention. Methods and techniques have been established to make building disassembly and salvage cost-competitive with complete demolition. Cost-competitive disassembly makes historic preservation and the adaptive re-use of properties the preferred option for sustainable development and pollution prevention. Admittedly, adaptive re-use of a building is much more labor intensive than new construction, but much less material and energy intensive. New building construction accounts for about 40% of the raw material consumption and 11% of total energy consumption each year. Energy that is embodied in a building is

completely sacrificed during demolition, and more energy must be incorporated into the process of demolition, debris removal and disposal. Adaptive re-use of a property through repair, alterations, and additions can conserve natural resources, cultural resources, energy, and landfill space. Adapting historic structures to meet changing military operations and organizational structures can sustain the natural and cultural environment through the "recycling" of physical features of the structure, the supporting infrastructure, the character of our cultural past, and the energy resources that still exist in the facility.

Tearing down serviceable buildings and disposing the wastes in landfills increase the amount of solid waste generated on a military installation and requires an increase in consumption of natural resources. Some beliefs hold that remodeling a historic facility generates more waste per square foot than new construction's estimated 3-4 lbs/ft^3 ; however, this statistic does not take into account the wastes from the demolition and removal of an existing structure on the site of the new construction. Common sense dictates that material reuse diverts construction materials from landfills and disposal. Demolition and dew construction (as well as renovation, but a lesser amount) can consist of all types of construction and demolition (C & D) debris: fixtures, finished building materials, building supplies, painted drywall, communication wires/cables, flooring materials, joists, roofing materials asphalt, concrete, etc. Since 15-30 percent of all wastes disposed of in landfills is C & D debris, a significant opportunity for reducing waste is through renovation. Not only can adaptive re-use of facilities reduce C & D debris, but renovation techniques tailored for historic building can also prove cost effective. Remolding project present the greatest potential for recycling materials and energy already embedded in the existing structure. Structural elements (i.e., footings, floors/ floor systems, concrete slabs, exterior walls/supporting walls, and roof systems), infrastructure (i.e., sewer lines, electrical/communication conduits, and stormwater/drainage areas), finished building materials (i.e., windows, doors, light fixtures, and bathroom fixtures), and building supplies (i.e., framing studs [metal and wood], joists, rafters, flooring materials, and headers) can be reused and/or retrofitted to renovate the existing structure to meet current organizational demands and new building requirements. Furthermore, any materials that do not have a potential to be used in the actual renovation of an historic facility, have the potential to be recycled into other products. Two such examples of high value waste products are metal, copper and aluminum, and cardboard. Other C & D debris such as wood, drywall, vinyl, and asphalt roofing can be recycled, but the availability and cost effectiveness of recycling these wastes varies by location.

CONCLUSION

Adaptive re-use of historic structures maintains the architectural and cultural integrity of structures while integrating modern technologies, new space requirements and sustainable development principles which are cost effective and prevent pollution. Knowledge, available technology, and policy development support the economic efficiency of restoration and adaptive use of historic properties as opposed to the demolition of an existing facility and new construction. The value that these renovated structures contribute to society and military installations is maintained in the socio-culture fabric that these historic buildings embody, the natural resources which are conserved, the energy which is saved, and the amount of solid waste

(in the form of C & D debris) which is diverted from landfills. The positive benefits of pollution prevention as well as sustainable development can be achieved by "recycling" the physical features, the supporting infrastructure, the character of our cultural past, and the existing energy resources that are present in historic properties.

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AF Case Studies in "Green" Specification Writing

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OVERVIEW

For many years the Air Force measure of success in delivering facilities has been: Did we build something that meets mission requirements within the established schedule and budget? Using these criteria, we've done a good job of providing buildings that meet our operational needs. Air Force project managers should not abandon these measures of quality, but need to broaden them to include new concepts. Today, a successful project should also conserve resources, avoid environmental degradation, and promote a healthy workplace. "Sustainable" is the term which is often used to describe projects which accomplish these goals. The "AF Environmentally Responsible Facilities Guide", now available on AFCEE's website, was written to help project teams create sustainable projects.

Executive Order (EO) 12873, Federal Acquisition, Recycling, and Waste Prevention, introduces the concept of environmentally preferable purchasing. Section 201 defines "environmentally preferable" as "products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service."

Section 401 of the EO states: "In developing plans, drawings, work statements, specifications, or other product descriptions, agencies shall consider the following factors: elimination of virgin material requirements; use of recovered materials; reuse of product; life cycle cost; recyclability; use of environmentally preferable products; waste prevention (including toxicity reduction or elimination); and ultimate disposal, as appropriate. These factors should be considered in acquisition planning for all procurements and in the evaluation and award of contracts, as appropriate." These EO requirements apply not only to newly written specifications, but also to the existing specification sections that we've used for years and continue to copy into new projects.

Setting goals to move projects toward sustainability is important, but is only the first step. Specifications are the key to getting these goals translated into specific actions that can be implemented in the finished project. If it isn't in the specs, it isn't going to get built.

This paper will walk through the specification writing process, beginning with a look at things you should consider in project planning. It will go on to describe some useful tools, and conclude with an overview of two Air Force construction projects that include sustainability in their specifications.

THINGS TO CONSIDER BEFORE YOU START

Sustainable design and construction are extremely broad topics. Answering three questions before you start writing the specs will help you focus your efforts:

⇨ What environmental requirements apply to the project?

⇨ What additional sustainability goals does the project owner have?

⇨ What is your implementation strategy: to develop comprehensive in-house sustainable project expertise, or depend totally on the design and construction firms, or land somewhere in the middle?

Consider Environmental Requirements: Project teams should already be familiar with environmental "compliance" requirements – the things we MUST do, like preparing environmental assessments or environmental impact statements, managing hazardous materials and waste, complying with toxic substance laws, and getting permits for air emissions and water discharges. Sustainability goes beyond these compliance requirements to prevent environmental and health impacts before they happen.

One way to conserve resources is to use products that are manufactured with recycled material content. EPA writes the "Comprehensive Procurement Guidelines" (CPG) to identify products that are commercially available with recycled content, therefore they are known as "Guideline Items." There are currently 36 Guideline Items. The items likely to be purchased for use in construction and landscaping projects include:

- Insulation
- Cement & concrete containing fly ash or ground granulated blast furnace slag
- Structural fiberboard
- Laminated paperboard
- Hydraulic mulch
- Compost
- Plastic fencing
- Playground surfaces
- Running tracks
- Carpet
- Floor tiles
- Patio blocks
- Shower and restroom dividers
- Latex paint
- Garden and soaker hoses
- Lawn and garden edging
- Plastic fencing used in controlling snow or sand drifting and as a warning/safety barrier in construction

Whenever EPA Guideline Items are used in a project, the specifications must clearly state our preference for products meeting EPA's minimum standards for recycled material content as stated in the CPG. To meet the intent of EO 12873, this preference should be extended beyond the Guideline Item requirements to make use of other recycled-content products as appropriate. "Preference" means that project teams will choose to specify, purchase and install recycled-content products whenever they meet reasonable performance, price and availability requirements. When adapting previously written specs for use in a new project, watch out for and delete all language that calls for the use of "new, prime material" or otherwise precludes the use of recovered materials.

"Buy-recycled" or "affirmative procurement" requirements are explained in detail in the Air Force "Guide to Buying Recycled". You can download this Guide and its Appendices from AFCEE at www.afcee.brooks.af.mil/EQ/ap-guide.htm.

The Federal Acquisition Regulation (FAR) Part 36.601-3 addresses EO 12873 requirements as follows:

- Statements of Work for Architectural-Engineer (A-E) services shall require the designer to specify use of the maximum practical amount of recovered materials (consistent with performance, availability and price reasonableness).
- The A-E shall also consider energy conservation, pollution prevention, and waste reduction in the specifications.

Consider Sustainability Goals: Installations and higher headquarters may have already defined a set of general sustainability goals for all projects, and users may set additional goals for individual projects. Early in the design process, the facility owner and designer should meet and agree on the sustainability goals for the project. These need to be acted upon throughout design and construction. Examples of goals from previous Air Force projects include:

- Preserving natural and cultural resources
- Creating facilities with healthful indoor air quality
- Conserving energy and water
- Managing, reusing and recycling Construction and Demolition (C&D) wastes

Consider Implementation Strategy: It's best to "think the execution through" for the entire design and construction process before you specify products and practices, so the team will be prepared for all required actions during bidding and construction.

How much effort do you want to put into specification writing? "Effort" in this case means the level of detail you put into the specs. There is a full spectrum of possibilities, ranging from writing general statements of preference for recycled materials and sustainable initiatives (and leaving it to the construction contractor to propose products and ideas you will have to review later), to doing detailed product research at the start of design (and writing specific requirements into each affected specification section.) In other words, where do you want to place your learning curve – at the beginning, while you are writing specs, or at the end, when you are confronted with questions from bidders or constructors?

What submittals will you require from the construction contractor, and who will review and approve the submittals? To understand the specs written by the A-E, and to effectively review building material submittals and proposed substitutions later on in the process, the project engineers and architects may need educational support. The "AF Environmentally Responsible Facilities Guide" is designed to be a resource for the design team. Ideally, a pollution prevention expert from the base environmental flight should help at all stages – acting as a consultant to define requirements, propose project goals, recommend "green" products or sources of information to identify these products, and review the specifications. The first project is the hardest and takes the most time. It gets much easier with the ones that follow.

What training will your construction inspectors need? Education is also needed for the Quality Assurance Evaluators (QAEs, or inspectors) who will monitor the project. In addition to their usual activities, they need to watch for construction practices that cause unnecessary environmental damage or otherwise fail to meet the sustainability requirements in the specs.

TOOLS FOR MAKING DESIGN DECISIONS

Before writing specs for the project you will need to make a lot of design decisions at the system level. For example, will it be a steel framed, wood framed or concrete structure? These are very general decisions. Specific product decisions will follow later. Try to tie the design decisions you make at this stage back to the environmental goals that were made at the start of project planning. For example:

- If maximizing the use of recycled content building materials is one of your goals, consider using steel framing (available with high percentages of recycled steel) and crushing demolished concrete slabs for reuse as aggregate in the new construction.

- If conserving energy is a goal, look at insulated concrete form construction or other specialized construction methods.
- If natural resource conservation is a goal, consider timber framing using sustainably harvested timber, and engineered joists that minimize the use of forest products.

Suggested tools for making system-level design decisions include:

American Institute of Architects (AIA) Environmental Resource Guide. Provides information on the environmental performance of different building materials. It is available through a subscription service and is updated periodically. AIA members can call 1-800-365-2724 to order at discounted rate. Ordering information is also found at www.aia.org.

Sustainable Building Technical Manual. Published in 1996 by Public Technology, Inc. with support from US Green Building Council, Dept. of Energy, and EPA. This manual has sections covering Economics and Environment; Pre-Design Issues; Site Issues; Building Design; Construction Process; O&M; and Issues and Trends. It provides a lot of detailed technical information in ways both engineers and environmental managers can understand, and is useful to both groups. The manual is free for downloading from www.sustainable.doe.gov (choose the "Toolkit" and look under "Green Buildings").

Once the basic design decisions have been made, it's time to locate and specify environmentally preferable building materials. Suggested tools for identifying products and manufacturers include:

EPA report, "Construction Products Containing Recovered Materials", and EPA Fact Sheet, "1997 Buy-Recycled Series - Construction Products" - www.epa.gov/epaoswer/non-hw/procure.htm

National Park Service "Sustainable Design and Construction Database" - free, but old (1995 data) – download the database from www.nps.gov/dsc/dsgncnstr

There are many other tools for environmentally preferable product selection. Most of them are available free of charge or for a nominal fee. For more links and leads, visit the DOE Center of Excellence for Sustainable Development's website at the address above, or the City of Austin, TX Greenbuilder Program's website at www.greenbuilder.com/general/BuildingSources.html.

TOOLS TO HELP WITH WRITING THE SPECIFICATIONS

Now that you've made your design decisions and identified products, it's time to start writing the specs (or editing previously used specs). Two suggested tools include:

GreenSpec: Guideline Specifications for Environmentally Considered Building Materials and Construction Methods. Available for $15 from Alameda County (CA) Recycling Hotline, (510) 639-2498. GreenSpec is a template that includes electronic specification sections and a user's manual. It includes model language for each of CSI divisions 1 through 16 to "cut and paste" into your specs. GreenSpec also includes a lot of general background information that helps to explain the environmental concerns associated with different building materials and specification sections.

WasteSpec: Model Waste Specification for Construction Waste Reduction, Reuse and Recycling. Available for $28 from Triangle J Council of Governments - information and an order form are found at www.state.nc.us/TJCOG/solidwst.htm#morespec. WasteSpec is a tool that's very much like GreenSpec except this one focuses on construction waste reduction techniques, material reuse and recycling. It also

includes model language for CSI divisions 1-16. The authors have also done a series of case studies from projects that used WasteSpec. In no case did it cost the owner money to reuse and recycle construction and demolition materials, even where the local landfill disposal ("tipping") fees were as low as $17/ton!

AIR FORCE SUSTAINABLE CONSTRUCTION PROJECTS

AFCEE believes that by observing and participating in sustainable projects, and developing case study information for crossfeed Air Force-wide, we can make it easier for other project teams to begin to include sustainability actions in their own projects.

Information about these projects is being placed on AFCEE's web page along with the AF Environmentally Responsible Facilities Guide. The Web page is a work in progress, so please bear with us as we develop it. The Design and Construction Directorate (AFCEE/DC)'s Design Group Division, and the Environmental Quality Directorate (AFCEE/EQ) are teaming on this effort. The Guide is linked to both directorate's pages, but as of the date this paper is submitted for publication, information on specification writing and case studies is only accessible through EQ's page. This is an interim fix. We're working on expanding and crosslinking the information. For now, please visit www.afcee.brooks.af.mil/eq/eqform.htm and look for the Sustainable Development link.

You may download the "Sample Specifications for AF Sustainable Construction Projects" document from EQ's page. This is not a complete set of specs – instead, it's a set of excerpts compiled from current projects. "GreenSpec" and "WasteSpec" already provide generic specification templates. Rather than duplicating them, this document is intended to show how these tools may be applied to AF projects.

Two of the case studies we're currently following are described in this paper:

Seymour Johnson AFB, NC (Air Combat Command): F-15 Squadron Operations Facility

HQ ACC selected this FY 97 MILCON project as the command's pilot sustainable construction project. Project goals emphasize construction and demolition (C&D) resource recycling, use of recycled-content building materials, and healthful indoor air quality.

With rare exceptions, the Corps of Engineers acts as the design agent for all AF MILCON projects. Savannah District is the design agent for this project and is responsible for managing the A-E contract. HQ ACC hired an architect with expertise in sustainability to act as a consultant to the project team. He took an active role in developing and reviewing the specs.

The project team spent a lot of time "up front" developing detailed sustainability language in the specs, starting with a 16-page "Sustainability" section and adding pertinent details throughout the other sections. A very ambitious goal of 75% recycling and reuse of C&D "wastes" was implemented by specifying a requirement for the construction contractor to prepare a Waste Management Plan and use a spreadsheet to track the disposition and costs for all C&D resources. You can download a copy of this spreadsheet from AFCEE/EQ's website along with the "Sample Specifications" document described above.

The Squad Ops Facility is currently under construction. The team's efforts to write complete and clear specifications have paid off, with no unusual construction problems or cost increases attributed to sustainability. Even so, the project's sustainability consultant believes improvement would be possible if

a more cohesive approach to spec writing were taken, or if standard "sustainable" guide specifications were developed. Generally, different spec sections are written by a variety of experts (landscape architects, interior designers, mechanical engineers to name a few), with the product being a document several inches thick. We also tend to copy specification sections from past projects for new project specs. The specs go "out for review" to all the experts, who look at their areas of concern, but the document is seldom read and edited as a whole.

Vandenberg AFB, CA: Construct Military Family Housing (Air Force Space Command) - 108 units

Vandenberg AFB is on the Central California coast in an environmentally aware and sensitive area. As a result the base already had established goals for natural resource preservation and restoration, energy and water conservation, and air quality. Adding to these, the list of sustainability goals for this project now includes reducing the solid waste disposed during demolition, construction and operations, and increasing the use of recycled-content building materials.

The Air Force acts as its own design agent for Military Family Housing projects, so the Corps is not involved. AFCEE/DC manages this project for AF Space Command. The AFCEE engineering project manager asked an AFCEE/EQ pollution prevention specialist to act as an environmental consultant. With HQ AFSPC's concurrence, we partnered with the Base design team to set sustainability goals. The AFCEE and Base design team and the A-E design firm then signed a formal Charter committing us to promote sustainability in this project and future Housing construction projects at Vandenberg. The Goals and Charter are available for download from the EQ website along with other documents developed during design of this project.

AFCEE made a lot of suggestions for products and practices to try. Some were welcomed by the base architects, and some weren't. They had the final say – it's their project, and they will have to live with it. The A-E firm was not selected with sustainable design experience in mind, and some personnel were hesitant at first to try new things. We had to convince them we were serious, and then they began to bring good ideas of their own to the project.

The completed Vandenberg specs require the construction contractor to prepare plans for management of non-hazardous waste; hazardous waste management and disposal; emergency response and spill prevention; and storm water pollution prevention. A new Section 01505, Construction Waste Management, was written using "WasteSpec" as a template. "GreenSpec" was also used. Energy efficient systems, products that minimize emissions of volatile organic compounds (VOCs), and recycled-content products are called out in affected divisions. We specified a requirement for the contractor to save, crush, and re-use "waste" concrete from the demolition of existing roads and slabs as aggregate in the new construction. The added design costs due to sustainability were minimal – the A-E estimated an extra 60 hours were spent on "greening" the design, and also stated it would not take as long to do it a second time. Project construction has not yet begun.

SUMMARY

To meet Executive Order requirements, all Federal project managers need to review and revise construction specifications to include recycled-content materials and other environmentally preferable products and practices. Preparing detailed specs requires up-front education and effort, but prevents confusion and costly mistakes when construction actually starts. The A-E must do the work, but the customer should set goals and be informed enough to make sound design decisions. The A-E is a resource; pick one that's experienced, but also keep watch to make sure your goals are being met.

Finally, follow through during construction and don't allow product substitutions to dilute the environmental benefits called out in the specifications.

Session II
Education and Training

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Environmental Services for Community Relations Program Support in Pollution Prevention Training and Education

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Pacific Air Forces (PACAF) installations are leaders in environmental compliance and pollution prevention (P2). PACAF supports the Air Force initiative to reduce compliance requirements through P2. Recognizing the importance of community awareness and support to the success of P2 initiatives, PACAF contracted Earth Tech, Inc. (Earth Tech), through the Air Force Center for Environmental Excellence (AFCEE), to support its P2 community relations program. The program targets a general audience, including base personnel, base residents, local community residents, and schoolchildren. Earth Tech conducted site visits to nine major PACAF installations in Alaska, Hawaii, Guam, Japan, and Korea to collect data, photographs, and video footage regarding P2 program activities. Additionally, personnel at Headquarters PACAF were interviewed to obtain command-wide statistics and information regarding program progress and future plans.

PACAF's P2 COMMUNITY RELATIONS PROGRAM

An important part of the community relations program is working with local communities to identify and take advantage of opportunities for the public and individual installation personnel to participate in P2 activities at work and at home. The individual installations foster community support and participation in P2 initiatives through recycling, household hazardous waste exchange, and a variety of events and projects throughout the year.

Hickam Air Force Base (AFB) hosts a visitor's center at their recycling location as part of their community awareness program. The center displays everything that is recyclable at Hickam AFB and also illustrates the environmental benefits derived from recycling. Step-by-step guides demonstrating how to set up office and household recycling programs are displayed on the center's bulletin boards.

Andersen AFB's "Wizard of Waste" instructs school-aged children in the benefits of recycling. Personnel in the Environmental Flight volunteer to visit the on-base schools as the "Wizard of Waste" to talk to school children about what can be recycled, why they should recycle, and how they can participate in the recycling program.

Eielson AFB participates in the Green Star Program, jointly established by the Anchorage business community, Alaska Center for the Environment, and the Alaska Department of Environmental Conservation's Pollution Prevention office. The program encourages local businesses to adopt environmentally sound business practices and creates a forum for exchange of ideas on cost-effective ways to reduce pollution. Participation requires adoption and circulation of a hazardous waste reduction policy, conducting internal assessments, providing incentives and training opportunities, and networking with other businesses to exchange information. Key elements of Eielson AFB's Green Star Program included implementing a Hazardous Materials Pharmacy (HAZMART), an Affirmative Procurement Program, and a Refuse Derived Fuel (RDF) facility. A Green Star was awarded to the base on 17 September 1996 during a presentation at the Fairbanks Chamber of Commerce luncheon.

Earth Day. A number of the PACAF installations sponsor special activities to celebrate Earth Day, typically in coordination with local communities.

- Misawa AB teams up with the local community to support Earth Day and the Japanese Green Day activities to promote P2 and the need for waste reduction. Activities have included the Misawa Fishing Port Clean Up, Oirase River/Gorge Clean Up, and a picture contest for local schools.

- In 1997, Anderson AFB personnel spent over 800 hours improving and cleaning up more than 7 miles of roads, 4 miles of beaches, and 2 miles of nature trails. Other activities included planting trees, cleaning up the base, and helping to clean up local villages and a wildlife refuge.

- Yokota Air Base (AB), Japan, has focused past Earth Day efforts on educating the youth in the community. Activities included composting demonstrations, a field trip to the Tokyo Metro Tama River Wastewater Treatment Plant, and the Tama River Clean Up. Community outreach includes setting up displays of environmental books and video tapes.

The second aspect of PACAF's P2 community relations program is to advertise to the on- and off-base community the techniques that PACAF is implementing in its daily operations that allow them to continue to support their defense mission while reducing pollution. Community relations efforts under this focus involve preparation of written and audio-visual materials that describe initiatives that have saved money and reduced use of hazardous materials and generation of hazardous wastes, or have helped conserve natural resources. Earth Tech's task was to support this aspect of the program by preparing fact sheets, a color brochure, and a video highlighting some of PACAF's successful P2 initiatives.

Fact Sheets. Earth Tech prepared four, 4-page, black-and-white fact sheets, which were provided to the P2 points-of-contact for general distribution at each of the nine major PACAF bases. Each fact sheet was developed around a specific theme, as follows:

- What is P2? To introduce the general reader to the principles and primary regulations and policies regarding P2. Addresses benefits of P2, the P2 hierarchy of Source Reduction - Recycling - Treatment - Disposal, and defines EPA-17 chemicals and ozone-depleting substances.

- Municipal Solid Waste and Recycling. Explains why we should recycle, and identifies types of materials that can be recycled. Summarizes initiatives at PACAF installations for recycling, provides suggestions for reducing waste, and describes actions that individual consumers can take to support recycling efforts.

- Reducing Hazardous Waste Generation. Defines hazardous waste and summarizes techniques that are being implemented at PACAF shops to reduce use of hazardous materials and generation of hazardous waste. Defines household hazardous waste (HHW) and provides suggestions for reducing and properly disposing of HHW.

- Celebrate Earth Day. Includes information about what PACAF installations historically and currently do to support Earth Day. Provides suggestions for Earth Day activities that communities and individuals can implement all year long.

P2 Brochure. This 16-page, full-color brochure summarizes P2 initiatives that are being implemented at PACAF installations. It highlights techniques in recycling, composting, hazardous materials purchase and distribution (HAZMART), household hazardous waste collection, corrosion control parts washers, solvent recycling, oil analyzers, antifreeze recycling, groundwater recharge, and pesticide reduction. The brochure also describes what PACAF is doing to educate and involve the on- and off-base communities in P2 activities.

Promotional Video. The 20-minute color video with voice-over narration demonstrates some of PACAF's P2 techniques. Using footage shot in shops, recycling centers, and at various other locations around the nine installations, the video highlights some of PACAF's innovative and cost-effective methods of reducing pollution. The narration is directed to a general audience to explain how PACAF is continually finding ways to reduce use of hazardous materials, generation of hazardous waste, and procurement and disposal costs in its day-to-day operations.

PACAF's P2 INITIATIVES

Site visits to the P2 shops at nine PACAF installations provided a great deal of information about successful PACAF P2 initiatives. These initiatives are summarized in the following paragraphs.

Municipal Solid Waste

- Hickam AFB established a state-of-the-art recycling center and saved over $900,000 in disposal costs by diverting the waste stream from the local landfill. Hickam AFB also coordinated with the Honolulu Resource Recovery Venture (HPOWER) to have its non-recyclable, nonferrous, solid waste burned in their Waste-to-Energy facility. Through the combination of aggressive recycling and using waste-to-energy, the base was able to reduce its annual solid waste disposal from 17,587 tons to an equivalent of 2,254 tons in 4 years, a reduction of 87 percent.

- Elmendorf AFB implemented Project Gold Flag, a recycling initiative under which aerospace ground support equipment or parts scheduled for disposal are instead salvaged, rebuilt and then reused. This project saved over $1,347,000 in disposal and acquisition costs in one year alone.

- Eielson AFB purchased an RDF Pelletizing Machine. The machine produces dense pellets from the solid waste; the pellets are burned as a coal substitute in the base's central heat and power plant. The installation saves over $250,000 a year in waste disposal and fuel procurement costs. The base recently signed a Memorandum of Agreement (MOA) with the Fairbanks Borough; under the terms of the MOA, the base will be able to dispose of one ton of noncombustible waste for every two tons of combustible waste from the borough. In this win-win deal, the base will realize additional savings on waste disposal and fuel costs, and the borough will be able to prolong the life of the landfill.

- Elmendorf and Eielson AFBs use oil heaters and smart ash burners that burn used oil or solvent-contaminated rags and used absorbent materials to heat various storage and industrial facilities. The greatly reduced amount of material remaining after burning is tested and typically found to be non-hazardous and disposed of as municipal solid waste. The bases benefit from (1) reduced shipping and disposal costs for used oil and hazardous waste, (2) reduced heating costs, and (3) reduced depletion of fossil fuel resources.

- Many PACAF installations have purchased glass pulverizers, which pulverize glass into usable products, instead of sending it out for disposal. Pulverized glass leaves no sharp edges and can be used as fill material for road bases, golf course sand traps, and beaches, and can be used as an aggregate in concrete, mortar, and asphalt mixes. Use of the glass pulverizer helps reduce disposal costs for glass as well as purchase costs for the created products.

- At several PACAF installations, including Yokota AB and Elmendorf AFB, fluorescent light bulbs are also recycled. First, the bulbs are processed through a fluorescent tube disposal unit that crushes the glass. During this process, any mercury associated with the fluorescent tube is vacuumed into a filter, allowing the glass to be recycled with other glass products.

- All PACAF installations recycle at least part of their green and wood waste. Although these operations are not conducted for profit, recycling green waste saves on disposal costs and on the cost

of landscaping materials. By recycling and reusing these organic materials, waste previously disposed of in landfills is put to beneficial use in gardening and landscaping.

- PACAF installations supply various recycling bins for industrial and office areas as well as Military Family Housing areas. To make recycling easy and accessible for all, PACAF installations use a combination of curbside recycling in housing areas and centrally located recycling bins throughout the installations where base personnel can drop off their recyclables at their convenience.

- At Kadena AB, Japan, a manpower shortage and the high cost of recycling using a local contractor made it difficult to implement a cost-effective recycling program. However, the base recently signed an MOA with the Marine Corps under which the Marines collect recycling and operate Kadena's facility and equipment, and the two forces split the proceeds. Everyone benefits, including the environment.

- Recycling does not yet pay for itself at all PACAF installations; however, funds received from recycling activities can be used to offset the cost of implementing recycling programs or used to improve or develop quality of life projects. Examples of such projects include new playground equipment, recreational equipment, and a skateboard park.

Hazardous Material/Waste Reduction

- By implementing the HAZMART and eliminating stockpiles of hazardous materials in individual shops, PACAF has saved thousands of dollars in disposal costs. In the first 3 years that the HAZMART was operational, Andersen AFB reclaimed/reused 34,000 items valued at over $214,000 and reduced their hazardous waste stream by 36 percent. Reissuing material saved Misawa AB over $16,000 in acquisition and shipping costs in only one year.

- All PACAF installations have implemented a household hazardous materials exchange operation. The exchange area is typically located at the recycling center or self-help shop where base personnel may conveniently exchange household hazardous materials. Personnel who no longer have a need for various household hazardous materials such as household cleaners, pesticides, oils, lubricants, paints, thinners, and antifreeze, may bring these materials to the exchange so that they may be reused by other base personnel.

Corrosion Control

- At Andersen AFB, instead of randomly assessing the amount of paint to be used for vehicle painting and disposing of all leftover paint, the quantity of paint mixed is calculated for the size of vehicle being painted. All mixed paint must then be sprayed onto the vehicle; any surplus paint is sprayed inside engine compartments, fenders, wheel wells, and the vehicle frame. The base has begun to use less toxic, more environmentally friendly paints as well.

- When thinner that is used to clean the paint gun no longer does a satisfactory job, it is mixed with undercoating or non-slip paint as a reducer and is used during the undercoating process or on non-slip surfaces. Implementation of this new approach has resulted in an average annual reduction of over 2,700 pounds of waste paint and related materials. At Elmendorf AFB, the civil engineering paint shop has reduced its annual disposal of used solvent from approximately 200 barrels to about 5 by utilizing a solvent recycler. Osan AB eliminated 330 gallons of waste solvent per month with their solvent recovery system.

- Kadena AB in Japan uses an automated corrosion control system for non-nuclear munitions. Using latex paint, the system has reduced paint usage from 600 drums/year to 300 drums/year, saving Kadena over $148,000 annually.

- All PACAF installations are converting from conventional spray paint systems to **High-Volume/Low-Pressure (HVLP) paint systems**. The newer paint guns have a transfer efficiency of approximately 60 percent, whereas the old guns had an efficiency of only 30 percent. Using these guns reduces paint procurement requirements - and paint emissions - by up to 50 percent because less paint is lost to overspray. Hickam AFB saved $14,000 in the first year of using HVLP guns.

- At Eielson AFB, the aerospace ground equipment (AGE) shop has implemented the use of pre-cut adhesive numbers for labeling equipment rather than spray-painting stenciled numbers. By implementing this procedure, the AGE shop has reduced its use of paint and disposal of masking material by over 80 percent.

Parts Washers

- PACAF has implemented the use of parts cleaning machines that use an aqueous biodegradable cleaning agent to reduce the amount of chemicals used and hazardous waste generated. Before procuring a parts washer, Osan AB's Wheel and Tire Shop spent $13,000 a year on solvent procurement and disposal. Now, instead of disposing of 200 gallons of waste every two months, the shops will be left with 10 to 20 gallons of waste sludge. Over the ten-year service life of the washer, Osan AB will save over $140,000. The Eielson AFB Armament Shop reduced the amount of hazardous waste generated from cleaning parts by approximately 70 percent.

- Hickam AFB utilizes a closed-loop wash rack system at its motor pool facility for light-duty pressure cleaning operations. This system removes oil, grease, soils, and most other contaminants and automatically re-circulates the cleaned water for reuse. The system does not require use of a sanitary sewer or an oil/water separator. The system contractor provides ongoing maintenance and support.

Oil Analyzers/Recycling

- PACAF has implemented the use of engine oil analyzers to determine the condition of the oil to eliminate needless oil changes. Although used oil is either recycled or reclaimed for fuel at all PACAF bases, reducing oil changes reduces costs for contractor disposal and for purchase of virgin oil. The oil analyzer considers the lubricity, state of additive contents and contaminants, and viscosity of an oil sample. At Andersen AFB, the transportation squadron has instituted the use of a secondary filter in many of their vehicles to further extend the life of the oil.

- Several PACAF installations utilize oil filter crushers and drum compactors to reduce the bulk of material being disposed. The filter bottom is cut off, the filter casing and any metal components are crushed and recycled, and the filter is compacted to retrieve any used oil. Some PACAF installations also operate a 55-gallon drum compactor that reduces the bulk or area required to dispose of this material.

- All PACAF installations have implemented the use of antifreeze recycling units to reduce the amount and cost of antifreeze purchased and disposed. Typically, used antifreeze containing trace contaminants such as lead, iron, copper, and zinc is disposed of as non-regulated waste or as a hazardous chemical, depending on the local regulations. The recycler separates the contaminants, which are disposed of as hazardous waste, from the antifreeze, which can then be reused.

- Several PACAF installations recycle their aerosol paint cans. A simple attachment to a 55-gallon drum punctures the aerosol can to release the propellant and any residual paint. The paint is collected in the drum and disposed of once the drum is full. Because the propellant (which is what causes the cans to be classified as hazardous waste) has been released, the aerosol cans can be collected and recycled as scrap metal.

- Many PACAF installations, including Eielson AFB and Osan AB, have implemented the use of explosion-proof vacuum recovery systems to clean up accidental spills or releases that were typically cleaned up with the use of absorbent material. The machine collects the liquids, which can then be recycled and reused or disposed. The use of absorbent material and the cost to dispose these materials is significantly reduced.

- PACAF installations have implemented the use of media blasting machines to remove paint from aircraft, vehicles, and other equipment. Using a medium, such as plastic, that can be recycled and reused eliminates the use of hazardous chemicals previously used for removing paint. The medium used in the blaster can be reused until it no longer meets specification. Then, depending on the metal content of the residual medium, it is disposed of either as solid or hazardous waste. The amount of material disposed of from this process is significantly less than the large amounts of hazardous waste associated with use of chemical wipedowns.

Pesticide Reduction

- Hickam AFB is the first Air Force installation to utilize the Sentricon Bait Station method of eliminating termites. The base is using this system on a trial basis; however, preliminary results are very promising. Instead of applying hundreds of pounds of chemicals directly onto the ground, bait containing less than 1 ounce of a chemical active ingredient is placed into the station. This chemical does not come in contact with the environment and is not harmful to humans or animals; the termite brings the bait back to the colony and infects the entire colony.

- At Kunsan AB, weeds and other unsightly vegetation that grow on the protective revetments were typically controlled using herbicide applications. However, the base has begun sealing or capping the revetments using steel, concrete, or caulking. This method of control deters unsightly weed growth in the future, resulting in long-term cost savings and reduction of herbicide application.

Groundwater Recharge

- At Andersen AFB, storm water is directed to low-lying areas that contain groundwater-replenishing wells and channeled directly to the aquifer beneath the base to replenish the groundwater supply. Spill plans are in place to prevent the introduction of hazardous materials into these replenishing locations. Replenishing wells located in areas that are highly susceptible to possible receipt of spill material, for example, near flightline storm drainage areas, are being considered for closure to further reduce the possibility of groundwater contamination. By reintroducing storm water to the aquifer, the base is able to assure an adequate water supply to support mission needs.

Web-based Solutions for Pollution Prevention Training

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Goal: The Department of Defense (DoD) is tasked to be a leader in pollution prevention, and a critical element of this mission is an effective workforce training program.

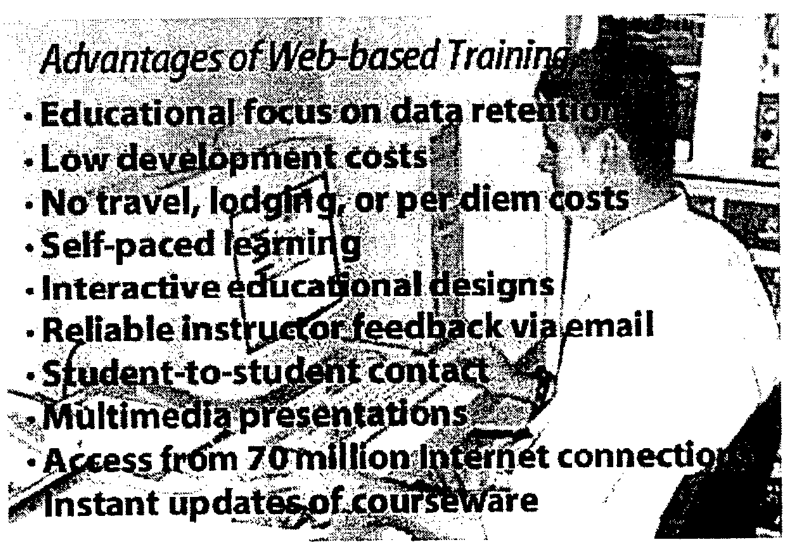
In 1993, President Clinton signed legislation requiring all federal agencies, including the armed forces, to comply with the Pollution Prevention Act of 1990.[1] Thereafter, all the major services within the DoD established policies designed to comply with the new pollution prevention regulations.

Problem: The DoD budget has remained essentially flat but its environmental and training budgets have declined since FY 1994.[2]

DoD agencies are now challenged not only by their increasingly vital mission of environmental leadership, but must also compete for dwindling training resources to be successful. This conflict between tasks and funding has led the DoD to interact with Industry to find and implement the most effective and cost efficient means of leveraging limited resources to achieve a mutually effective environmental leadership role in pollution prevention.

Solution: Web-based pollution prevention training for service personnel.

Internet- or web-based training enables students to complete a course using a computer, without ever having to enter a traditional classroom. With only access to the Internet, the student can choose from a large course catalog and complete their training at their own pace, when their schedule allows.



Justification: Recent research into the field of Internet training has justified this new training delivery system. A study administered at the California State University at Northridge reported that students participating in a course delivered online achieved 20 percent higher in test scores and data retention than students presented with the same material in a traditional classroom.[3] One reason for the student's success was the surprising finding that students online spent 50 percent more time working together, via email and chat rooms, than students in the classroom. The conclusion of the study: **Web-based training is effective.**

This new, more effective training delivery system arrives none too soon for DoD applications. The American Society for Training and Development estimates that work related education costs $210 billion each year and that 78 percent of these costs are the result of lost productivity and expenses incurred while attending training.[4] In fact, most reports on the results of web-based training report a 35%-45% decrease in training time, with equivalent or better learning gains in terms of remembering and using the new knowledge.[5] Online educational alternatives and supplements offer solutions to minimizing training time without sacrificing desired training results. The conclusion: **Web-based training is efficient.**

Training Approaches Matrix	Classroom Training	Traditional Distance Learning	Web-based Training
Low cost for travel, lodging, and per diem		●	●
Low cost of course delivery per student		●	●
Large number of trainees easily accommodated		●	●
No training facility required			●
Interactive instructional design	●		●
Active instructor involvement	●		●
Easy access to reference information			●
Flexibility in training schedule		●	●
Centralized storage of student records			●
Productivity maintained while training			●
Ease of updating course content			●

Online training offers the convenience of other distance learning programs, but combines key elements of the classroom experience to make the learning more effective and interesting. All courseware or materials from training commands can be adapted and made available to personnel from one Internet address and training page. Internet-based training is easy to use, easy to access, and can be very effective. The primary advantages for the military or government user are lower overall cost; immediate, continuous, and flexible accessibility; desktop delivery of materials; and immediate updates to keep material current.

Several DoD agencies have begun to explore and exploit the potential for training over the Internet. Below are three case studies that illustrate how particular problems have been solved by web-based training.

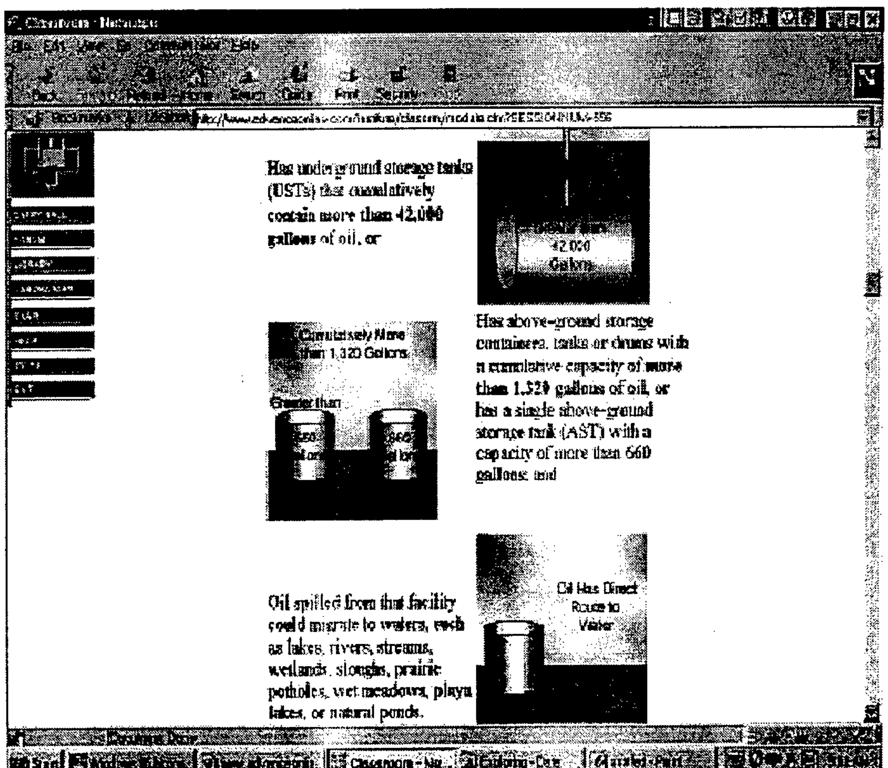
Case Study: An Online Institute for a Leading Provider of Navy Training

Problem: The Civil Engineer Corps Officers (CECOS) provides courses for Civil Engineers Corps officers, Seabee chief petty officers, foreign officers, civilian DoD employees, and officers from the Navy and other branches of the armed forces. CECOS currently offers 32 environmental compliance courses hosted at various locations around the continental U.S. and the world.

Writing travel orders for personnel to attend these courses is expensive, and for some attendance is a logistical impossibility. New delivery systems are required to service personnel and customers who either cannot attend traditional classes or require certification immediately and cannot wait for the next available course opening.

Solution: AdvanceOnline, Inc., a Seattle-based company that develops environmental compliance courses for delivery over the Internet, created an Online Institute with four trial courses for CECOS. The goal of this project is to test web-based courseware and to determine if it is a viable solution to the needs of CEOCS's clients. The courses include a demonstration course which teaches new students how to use the Online Institute, a SPCC course specifically tailored for CECOS, and an eight hour Hazardous Waste and Emergency Response Refresher (HAZWOPER) course.

CECOS personnel worked with AdvanceOnline project managers and technical writers to develop this Online Institute. For example, the SPCC course covers the EPA's requirements in the 40CFR, but was customized to meet the needs of CECOS. The result was a two-module SPCC course to train new operators, experienced operators, and first-line facility supervisors.



A typical segment of the AdvanceOnline SPCC course offered online.

Case Study: U.S. Army Corps of Engineers Seminar Program

Problem: The Army Corps of Engineers Waterways Experiment Station (WES) is one of the chief caretakers of dredging regulations for both military and civilian applications. As such, a large number of personnel and customers turn to the Corps for information about dredging strategies and technology, and WES is tasked with disseminating this information to as broad an audience as possible.

WES has established a seminar program for the dredging community that addresses both local and national issues pertaining to sediment removal. Due to the high cost of sponsoring and attending these seminars, some regions can only afford to send a limited number of personnel each year. Also, new members of local dredging communities must frequently wait an entire year before a meeting is held and they have the opportunity to meet with other colleagues and participate in these seminars. A central location where information could be accessed by all interested parties and frequently updated was required to succeed in WES's mission of data distribution

Solution: A customized solution was created by AdvanceOnline that addressed the Corps' communication needs. The goal of this program is to enhance year long communication between the Corps and their clients. First, an Online Institute was created with the specific information requirements of WES in mind. Next, documents and courseware were formatted and developed for delivery over the Internet.

Using the company's Internet technology, users can download information, take courses on common dredging, sediment remediation, and water quality issues, and use internal email forums to communicate with one another. Intended to supplement the existing seminar program, these online communication tools will allow members to be in contact as new issues arise, and enable new members of the dredging community to share in a common base of information.

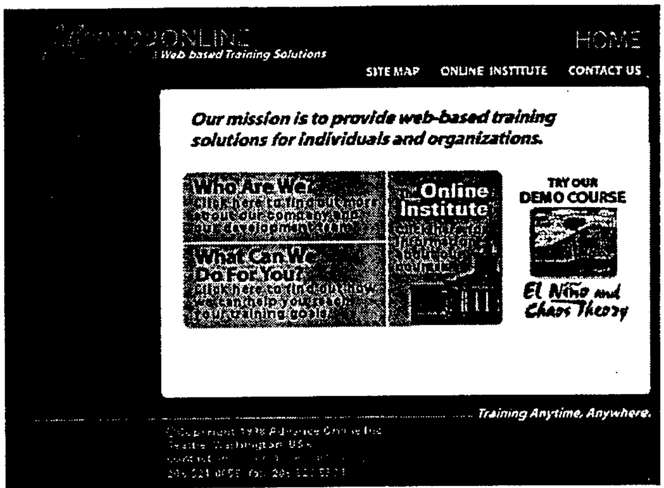
Case Study: Web-based SPCC Training for the Navy

Problem: Naval Undersea Warfare Center, Keyport is tasked with training a multitude of workers and service personnel with Spill Prevention Control and Countermeasure (SPCC) plans and procedures. First, these personnel must be aware of the implications of an oil spill and carry out management practices that insure a safe and spill-free site. Secondly, they must be familiar with the site's SPCC plan and well versed in the execution of its inspection procedures. Maintaining a current state of training in SPCC management is a constant struggle and stretch base resources too thin.

Solution: To alleviate the pressure on the Keyport SPCC trainers, an additional section was added to the pre-existing SPCC awareness course offered online by AdvanceOnline. This new module emphasizes risk management as a motivator for following site-specific SPCC plan inspection procedures. Focused on the visual inspection of storage sites, the SPCC course allows trainers to build an awareness of the consequences of an unwanted discharge of oil, and reinforce the best management practices the Navy uses to prevent such accidental spills.

Innovative Web-based Training Solutions:

In each of the above case studies, DoD training managers were searching for cost effective, high-quality training that would allow them to meet their broad training requirements with limited resources. Assessing all the available options (e.g., CD-ROMs/multi-media, videotapes, distance learning, video conferencing), and considering that the number of adults who use the Internet is rapidly increasing each year, web-based training provided the Ideal solution to their challenges.



www.advanceonline.com

Internet courses have several advantages over traditional classroom learning and other distance learning techniques. The goal of Internet delivery is to put the best elements of traditional classroom instruction into a convenient format, and there are many distinct advantages to web-based training:

- **Training flexibility**. Students can register for and enter classes at any time. Further, students can take a course on their own schedule and have the option of doing their training off-hours, including nights and weekends. Work schedules do not have to be impacted and productivity can be maintained.

- **Optimized learning.** In a classroom the instructor, who must cater to the needs of the entire class, sets the pace for learning. As a result, the fastest learners may become bored and the slowest learners may become frustrated. With the web-based training, the student can stop, start, review, or skip sections according to their knowledge, schedule, and pace.

- **Reduced travel.** Students can take courses at the convenience of home or the workplace without traveling to training centers.

- **Immediate updates.** Suppose that a federal regulation in a Spill Prevention Control and Countermeasures (SPCC) course has changed. Modifications to the on-line SPCC course can be done quickly, so that students can get the correct regulation information almost instantly. Courses can also be easily updated to keep pace with advances in technology.

- **Cost savings.** The student and his/her organization saves money through drastic reductions in overall training costs per student over traditional classroom courses. These cost savings are immediately realized by eliminating travel, lodging, and per diem expenses.

Methodology of Online Courseware Delivery

Training is vital to maintaining a workforce that is skilled, productive, competitive, and, for many industries, in compliance with regulations. However, traditional instructor-based training can present many challenges to organizations: ensuring consistent and high-quality training, keeping materials current, reaching large numbers of students including those in remote locations, and managing rising costs.

Online training provided by AdvanceOnline operates through two pathways: industry-specific courses published in our Online Institute and customized client services. The goals for publishing and client services are the same: to provide students with high quality training by maximizing the flexibility of the Internet.

The graphic below shows the components that an online course could contain and a brief summary of each:

Classroom – Students participate in course modules in the Classroom, so think of it as the place where the student learns the material.

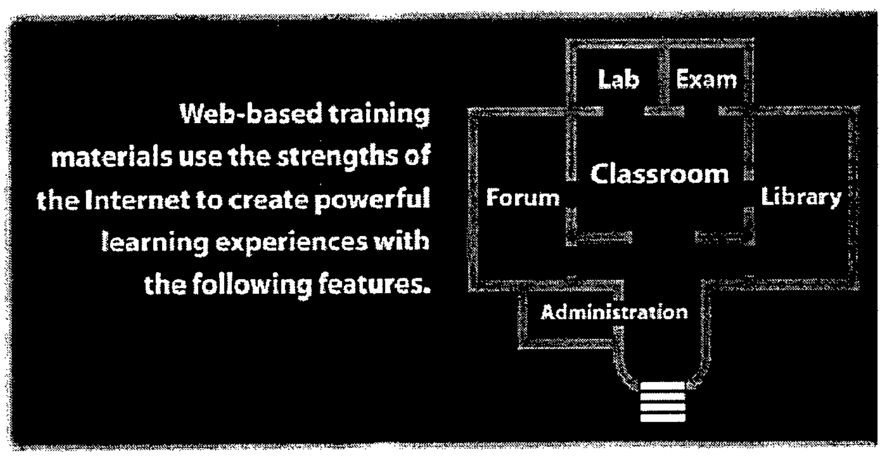
Laboratory – Students engage in interactive exercises to reinforce the Classroom material. This is an excellent way of improving your knowledge of the subject matter.

Library – Links students with outside reference material and data resources that are available 24 hours a day. This supplements the Classroom material.

Forum – The Forum is a critical element to the educational goals of online leading, as it connects students with other students and students with instructors via e-mail. Students can ask questions about content and discuss results of exercises with other students.

Exam Room – Upon completion of the module, students can test what they know. Multiple choice questions to assess knowledge and measure achievement are used.

Administration – Students can change passwords, check their progress and grades, and change personal information.



Conclusion:

Web-based training is proving to be a viable and cost efficient alternative to traditional pollution prevention training. By offering effective and efficient training solutions online, DoD clients are better prepared to achieve their mission objectives of defense preparedness and environmental leadership.

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[1] Executive Order 12856
[2] Goodman, Sherri, Under Secretary of Defense (Environmental Security), 11 March 1998 speech
[3] Black, Jane. "Online Students Fare Better," CNET News.com, 17 January 1997.
[4] Dennis, Verl E. "How Interactive Instruction Saves Time," Journal of INSTRUCTION DELIVERY SYSTEMS, Winter 1994.
[5] Allen, Rex. "It's a Circus Out There," CBT Solutions Magazine, 1998.

Online training provided by AdvanceOnline operates through two pathways: industry-specific courses published in our Online Institute and customized client services. The goals for publishing and client services are the same: to provide students with high quality training by maximizing the flexibility of the Internet.

The graphic below shows the components that an online course could contain and a brief summary of each:

Classroom – Students participate in course modules in the Classroom, so think of it as the place where the student learns the material.

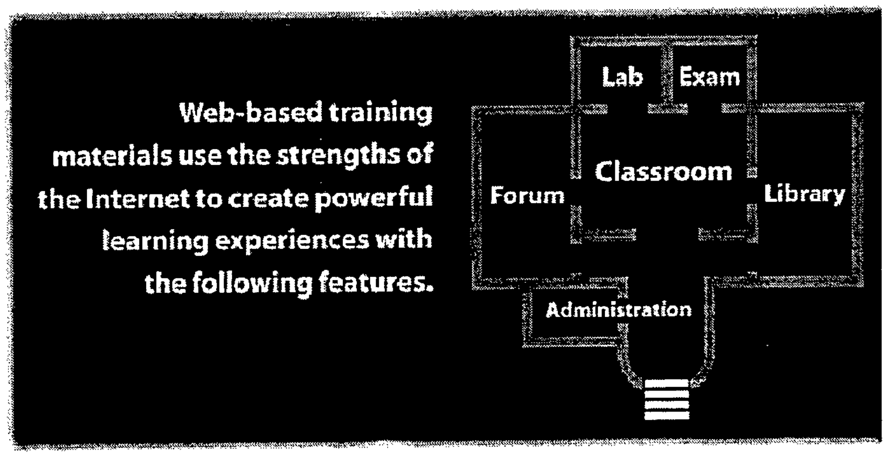
Laboratory – Students engage in interactive exercises to reinforce the Classroom material. This is an excellent way of improving your knowledge of the subject matter.

Library – Links students with outside reference material and data resources that are available 24 hours a day. This supplements the Classroom material.

Forum – The Forum is a critical element to the educational goals of online leading, as it connects students with other students and students with instructors via e-mail. Students can ask questions about content and discuss results of exercises with other students.

Exam Room – Upon completion of the module, students can test what they know. Multiple choice questions to assess knowledge and measure achievement are used.

Administration – Students can change passwords, check their progress and grades, and change personal information.



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[5] Allen, Rex. "It's a Circus Out There," CBT Solutions Magazine, 1998.

POLLUTION PREVENTION TRAINING INNOVATIONS AT ARNOLD AIR FORCE BASE

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Science Applications International Corporation
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This paper describes two related pollution prevention (P2) training initiatives underway at Arnold Air Force Base (AFB) aimed at equipping the workforce to identify reduction opportunities in the workplace. Developing innovative training and providing new educational opportunities to Base employees are of paramount importance in achieving additional reductions in hazardous material use and waste generation. A detailed account of both a recently developed computer-based opportunity assessment (OA) training package and a shop-level training approach under development is included.

Introduction

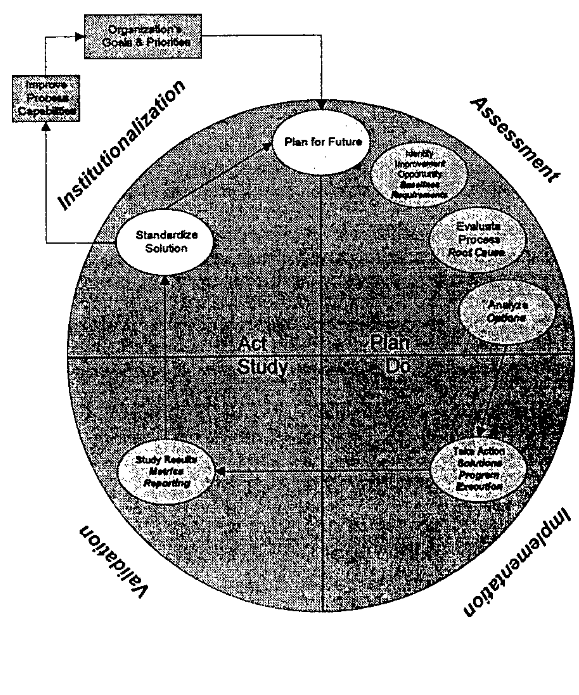
Arnold AFB is one of three test centers within the Air Force Materiel Command. Named for the first General of the Air Force, Henry H. "Hap" Arnold, it is situated on a 40,000-acre reservation in southern middle Tennessee. Arnold Engineering Development Center (AEDC), where the testing is conducted, encompasses a 3,600-acre industrial area. The Base population is 3,250, comprised of Air Force staff and two primary civilian contractors, Sverdrup Technology, Inc. (SvT) and Aerospace Center Support (ACS).

The Air Force staff, numbering around 300 and split equally between military and civilian personnel, provides management, resource allocation, and contract administration for the facility and its specialized operations. SvT is responsible for conducting propulsion and flight dynamics testing, while ACS serves as the center support contractor. Science Applications International Corporation (SAIC) provides additional specialized support to the Base environmental programs.

AEDC is the most advanced and largest complex of flight simulation test facilities in the world, with fifty-three aerodynamic and propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, arc heaters, ballistic ranges, and other specialized units. Twenty-seven test units possess capabilities unmatched in the United States; thirteen are unmatched in the world. Facilities can simulate flight conditions from sea level to altitudes around 100,000 feet, and from subsonic velocities to those well over Mach 20.

Description of Pollution Prevention Program

AEDC has been actively involved in waste reduction efforts for a number of years. However, 1996 was a critical juncture in the P2 program. That year, a Strategic Plan was developed to guide the efforts of the P2 Integrated Product Team (IPT), which was formed that same year. One of the most critical decisions made in the early stages of the program was the adoption of a P2 process methodology, based on Air Force P2 guidance and the Quality Air Force (QAF) quality cycle. The methodology incorporated root cause analysis in the assessment phase of the process in an effort to better focus efforts on the "front of the pipe."



Following the vision of the Strategic Plan, and utilizing root cause principles in the investigation of reduction opportunities and subsequent development of P2 options,

a number of focused studies were conducted. This assessment effort addressed a number of major opportunity areas, including hazardous wastes, municipal solid wastes, and non-RCRA wastes (i.e., those wastes that are not regulated but cannot be disposed of on site). In addition, the Base-wide OA was updated last year to reflect the status of P2 efforts and identify additional improvement opportunities.

As part of the "fence-to-fence" OA update, SAIC was tasked with several other related initiatives, including the updating of an existing process material usage and waste generation database, the formatting of this information for input into the Geographic Information System (GIS), and the development of OA training for Base personnel. The latter was viewed as a means to more fully realize the benefits of P2 through institutionalizing P2 principles into Base operations. Furthermore, the effort to "operationalize" P2 is viewed as an important element in the Base meeting its strategic objectives to streamline business practices, increase efficiency, and reduce the overall cost of the testing process.

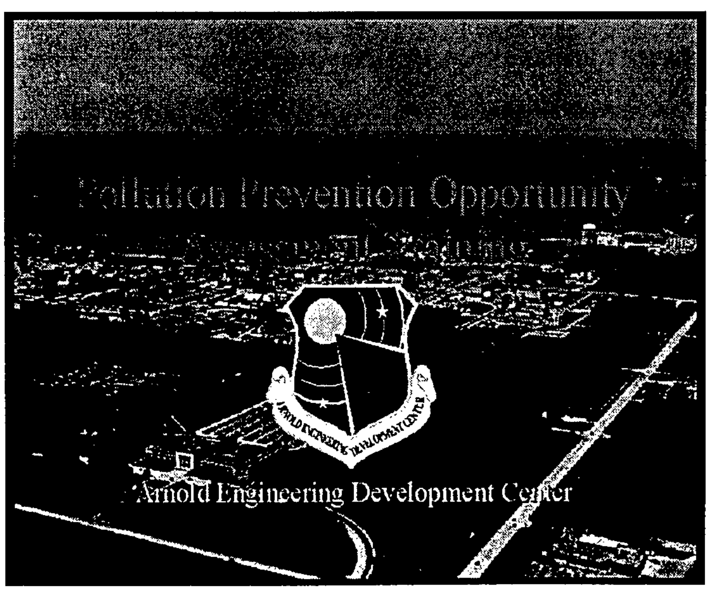
Purpose/Goal of Training

Effective training is a critical factor in implementing change within a process or an organization. In the workplace, it provides the means to disseminate needed information, and indoctrinate and educate employees on new concepts and new ways of doing things. When basic instruction is augmented with real-world applications, it serves to reinforce desired actions and behaviors and thus institutionalize change within the culture.

As pollution prevention is a concept of change - that being to find new and better ways of performing tasks to reduce inefficiencies and wastes - developing and applying effective P2 training initiatives can pay huge dividends. This is particularly true in light of the present financial constraints imposed by budgetary reductions and a very competitive marketplace.

P2 awareness training has been provided to Base employees in the past. To develop a fuller understanding of P2 and its potential benefits, additional training for the general population was felt to be in order. This training is directed at providing personnel a good understanding of P2, both historically and conceptually, as well as a good working knowledge of the OA process (i.e., what is the thought process, what are the basic steps, etc.). Additionally, more in-depth, hands-on instruction was felt to be in order for employees engaged in particular Base activities. Thus, an effort to develop and conduct shop-level P2 training for selected operations has been initiated.

Phase I - Opportunity Assessment Training



At the outset, it was recognized that the audience would be quite varied, from new hires to seasoned veterans, from clerical staff to testing engineers to maintenance mechanics, and that the core knowledge of Base employees pertaining to environmental matters would range from very knowledgeable to nonexistent. As such, it was deemed crucial that the presentation approach offer as much flexibility as possible.

After careful consideration, the decision was made to develop the training as animated, interactive Power Point slide shows with embedded WAV files providing full narration. This format offers considerable flexibility in providing instruction to virtually any audience. For instance, the files can be placed on a server

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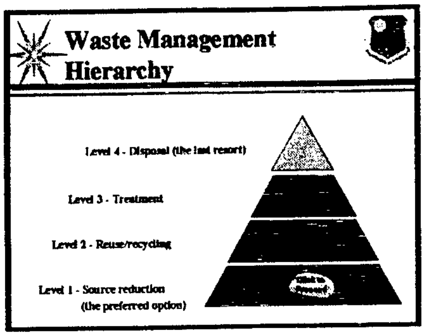
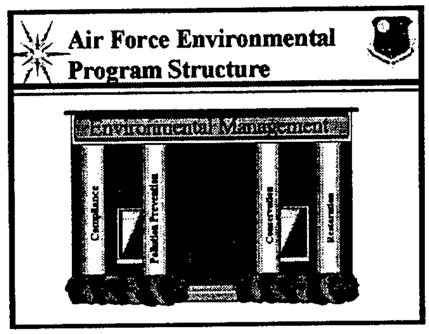


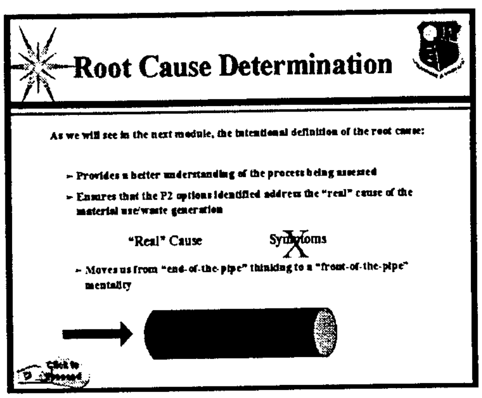
Core Module 1 – History of Pollution Prevention

To provide the student with an historical perspective of P2, the first core module deals with the history of pollution prevention. Topics include population growth and technological advancements, early legislation enacted to address pollution, industry's realization that "front-of-the-pipe" initiatives save money, the passage of the Pollution Prevention Act of 1990, and the waste management hierarchy.

Core Module 2 - Air Force Pollution Prevention Strategy

To provide an understanding of how and when Air Force P2 initiatives came into being, Module 2 provides a brief overview of the Air Force P2 Program. The basic four-pillar structure of the Air Force environmental program is discussed, as is its P2 strategy. In addition, metric reduction goals for major protocol areas (e.g., solid wastes) are reviewed. The student is also introduced to the P2 process methodology, or pollution prevention opportunity assessment (PPOA) process.



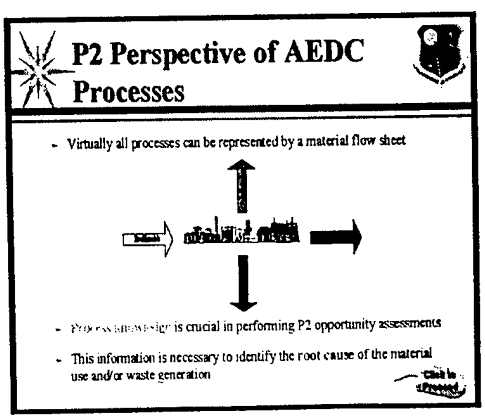


Core Module 3 - AEDC Pollution Prevention Program

The OA training package also provides an overview of AEDC's P2 Program and illustrates how it supports the mission and vision of the Base. The topic of "compliance through P2" is discussed, and the concept of root cause analysis is introduced as a means to more effectively target "front-of-the-pipe" solutions, identify additional waste reduction opportunities, and develop effective P2 options that address the real reason(s) that toxic materials are used and wastes are generated. In preparation for a more in-depth discussion of the OA process in the next module, Module 3 closes with a brief overview of the four quadrants of the AEDC P2 process cycle.

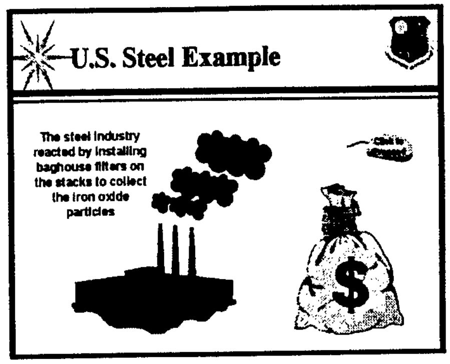
Core Module 4 - The Pollution Prevention Opportunity Assessment

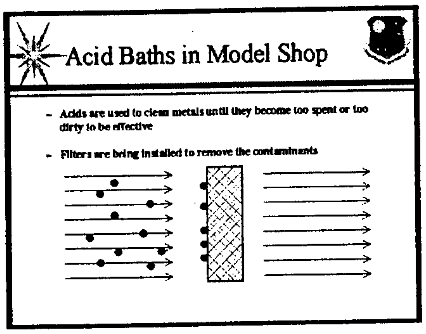
While the previous modules provide the background and rationale for pollution prevention efforts, Module 4 provides the student with specific information on the OA process itself. As it is the focus of the training, it is much more detailed and of longer duration than previous modules. The module begins with a brief overview of the material life cycle and how to construct flow sheets describing a given process. Following a review of the AEDC P2 process cycle, each of the six steps in the assessment phase is described in detail. Criteria to consider, questions to ask oneself, and the importance of identifying root causes for the use of toxic materials and the generation of wastes are covered. Generic categories of potential P2 options are reviewed to stimulate the student's thinking. In addition, criteria



for evaluating options are discussed, such as the technical and economic feasibility of initiatives. Finally, information pertaining to the formal prioritization of projects for funding consideration is covered, along with an overview of the P2 project funding cycle.

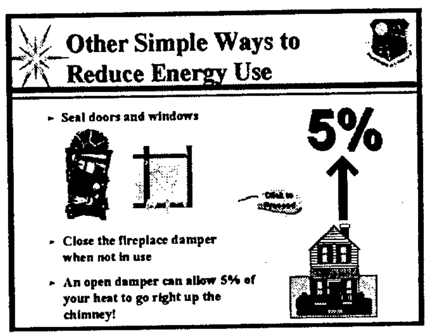
In closing, the value of root cause determination is illustrated through a real-life example – a case study from United States Steel. This example serves as a backdrop for the next module, which deals with P2 success stories from the military, from AEDC, and from private industry.





Core Module 5 - Examples of Pollution Prevention Successes

As mentioned in the preceding section, Module 5 provides a number of real-life successes stemming from the effective application of P2 principles in a variety of circumstances. Military and industrial operations are covered, including a number of local success stories.



Summary Module

In addition to providing a review of some of the key points covered in the training, the summary module provides examples of how to apply P2 at home. An emphasis is placed on recycling and energy/water conservation. As the module closes, information pertaining to Base P2 points of contact and the availability of a P2 information package is provided.

Pollution Prevention Opportunity Assessment Training for AEDC is currently available on CD-ROM for Office 95 use. An Office 97 training package is being prepared at the present time. In addition, it is planned to place the training package on the Base environmental server once a proposed memory upgrade is completed. All Base employees will be provided the opportunity to receive this training.

Phase II - Shop-Level Pollution Prevention Training

As a follow-on project to the Phase I effort, and a logical progression in the continuous improvement process, shop-level P2 training is being developed for specific target audiences to reinforce and expand the concepts presented in previous training initiatives. This training will provide hands-on instruction to effectively demonstrate how to identify and assess waste reduction opportunities in the workplace. The target audience for this training is Base personnel involved in those activities determined to be key waste reduction opportunity areas. This determination will be based on AEDC experience and available metric information from various sources, such as the process database described earlier.

The shop-level effort will involve the development of P2 reference manuals and facilitation of their use within the workforce. Previously prepared training materials (e.g., OA training modules) will be utilized to the extent possible to both maintain consistency and reduce development costs. The manuals will contain the following information:

- Refresher instruction on P2 concepts and assessing P2 opportunities - *Generic*
- Tools for conducting opportunity assessments (i.e., flowsheets and checklists) – *Generic*

- Process-specific information (e.g., quantities of hazardous materials in use) – ***Shop-specific***
- Pertinent P2 successes from AEDC, other military installations, and/or industry – ***Shop-specific***
- A listing of P2 reference sources - ***Generic***

As indicated above, P2 tools and references are being developed in the course of this work. This information contained in the P2 reference manuals will be generic to all shops and/or activities. As such, this information can be incorporated into subsequent manuals, thereby allowing the preparation of additional manuals at a smaller incremental cost than would otherwise be the case. This will provide for the timely preparation of additional training materials as Base priorities and available resources dictate.

Once manuals are prepared for a targeted shop, an instructional session will be held with shop personnel following a generic lesson plan. These sessions will provide an opportunity to conduct the following:

- Discuss the purpose and application of the manual
- Review basic P2 concepts and the OA process
- Review case studies to enhance understanding of basic principles
- Review P2 tools included in the manual and discuss their application
- Facilitate student participation in example exercises (preferably ones that have particular significance to the involved shop)
- Review related P2 successes and P2 reference sources

It is envisioned that these sessions will consist of several brief presentations, each of which will be followed by exercises, with environmental staff members and/or prior "graduates" of the course serving as facilitators.

As a means to "hold the gains" and ensure that momentum is maintained, it has been proposed to hold periodic "alumni" meetings of personnel who have completed shop-level training, to provide a forum for reporting and comparing results, sharing lessons learned, and discussing common issues of interest. Also, recognition of employees who make the effort to put their newfound knowledge into practice is seen as a high priority to further energize the program.

Summary

As a companion effort to the recent Base-wide OA update, AEDC has developed a Power Point-based training package, providing the capability to offer both individualized instruction via interactive PC-based slide shows, and group instruction via computer or conventional overhead projection. In addition, to reinforce the concepts presented, shop-level training that will provide hands-on application of P2 principles is being developed.

By integrating innovative instructional techniques with field exercises, and placing user-friendly OA tools in the hands of Base personnel most knowledgeable of shop operations and processes, Arnold Air Force Base is striving to achieve its stated environmental vision, "a model of environmental excellence."

Arnold Engineering Development Center

National aerospace preeminence through AEDC, the test & evaluation center of choice for our customers, the workplace of choice for our people, and **a model of environmental excellence** *for our communities.*

ENVIRONMENTAL SHORT COURSES AT THE
AIR FORCE INSTITUTE OF TECHNOLOGY

Mr. Randall Schober & Mr. Neal Hauschild
Department of Environmental Management
Air Force Institute of Technology
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Wright-Patterson AFB, OH 45433
Tel (937) 255-5654
Fax (937) 255-4645
HYPERLINK mailto:rschober@afit.af.mil rschober@afit.af.mil or HYPERLINK mailto:nhauschi@afit.af.mil nhauschi@afit.af.mil

OVERVIEW: The Air Force Institute of Technology (AFIT) provides defense-focused graduate and continuing education, research and consultation to improve Air Force and joint operational capability. The Civil Engineer and Services School (CESS) is one of AFIT's four resident schools. CESS develops and delivers civil engineer, environmental, and services professional continuing education; provides consultation; and conducts applied research in support of U.S. aerospace forces. CESS offers a variety of environmental courses covering all media. In addition to the Inter-Service Environmental Education Review Board-approved (ISEERB-approved) Pollution Prevention Program Operations and Management course (ENV022), we have other ISEERB-approved courses (Environmental Compliance Assessment, ENV020 and Air Quality, ENV531). These courses are available to all services. Additionally, we have two brand new environmental courses entitled Hazardous Material Management Program (ENV222) and Unit Environmental Coordinator (ENV220).

ENV 020 - Environmental Compliance Assessment

OBJECTIVE: For each student to comprehend the objectives, principles, and mechanics of an environmental audit/assessment. (Called ECAMP in the Air Force, ECAS--Environmental Compliance Assessment System in the Army, and ECE--Environmental Compliance Evaluation in the Navy). At the end of the course, the students should have the knowledge to successfully plan and execute an internal or external assessment, prepare required reports, and direct the follow-up actions such as programming for environmental requirements. DESCRIPTION: This course provides the detailed management philosophy behind the various aspects of an

environmental assessment. Graduates will develop skills needed to serve as either a team chief or team member. The student should leave the course ready to assist their installation in performing internal assessments and in hosting an external team by developing an in-depth understanding of the program, a familiarity of team responsibilities, and environmental compliance programming avenues. PREREQUISITES: Primary Audience - Environmental Compliance Assessor (ECAMP, ECAS, ECE/both CE and Non-CE), ECAMP/ECAS/ECE Program Manager, Environmental Compliance Program Manager. Secondary Audience - Environmental Flight Chief, Enlisted Environmental AFS, Unit Environmental Coordinator (CE and non-CE), Environmental Program Manager (CE and Non-CE). Duration: 1 Week. **ISEERB approved for all DOD Components. POC: Mr. Randall Schober @ 937-255-5654, extension 3535.

ENV 022 - Pollution Prevention Program Operations and Management

OBJECTIVE: For each student to comprehend the objectives, principles, and mechanics of an installation pollution prevention program. At the end of the course, the students should have the knowledge to successfully plan, establish, and execute a successful pollution prevention program. Students should be able to direct follow-up actions such as selling the program to senior leadership and programming for pollution prevention requirements. DESCRIPTION: This course emphasizes pollution prevention concepts such as source reduction of hazardous and toxic chemicals, solvent substitutions, reuses and recycling, process changes, and environmental awareness. This course also introduces management techniques that can be used to implement a sound pollution prevention program. These management techniques include ways to establish and run the program, conduct pollution prevention opportunity assessments (class exercises included), implement process changes to incorporate pollution prevention, assess pollution prevention program success, and establish awareness training. PREREQUISITES: Primary Audience - Pollution Prevention Program Manager, Environmental Compliance Program Manager, and persons with primary P2 responsibilities in their respective organizations. Secondary Audience – Environmental Program Managers. Duration: 1 Week. **ISEERB approved for all DOD Components. POC: Capt Jeff Rumrill @ 937-255-5654, extension 3540.

ENV 220 - Unit Environmental Coordinator

OBJECTIVE: For each student to comprehend the daily environmental management requirements of a typical USAF organization, and what it takes to communicate and orchestrate these requirements both within and outside their organization. As a secondary objective, this course seeks to increase general environmental awareness and how all USAF members act as a team in managing environmental issues. DESCRIPTION: This course equips the unit environmental coordinator (UEC) to improve and maintain environmental compliance within their organization, recognize and address problems when they occur, and act as base-wide point of contact for environmental issues concerning their organization. Key topics discussed include the UEC appointment process, the structure, role and function of the base Environmental Protection Committee (EPC) and Environmental Management office (EM or CEV), how to interact with the Environmental Protection Committee and Environmental Management, and what tools are available to help UECs do their job. In addition, key functional responsibilities will be discussed. These include the management of hazardous materials and waste, solid waste,

water discharge, air emissions, petroleum products, and ongoing pollution prevention. Other program management guidance will be provided which covers special concerns of pesticides, PCBs, asbestos, noise, environmental planning, and natural and cultural resources. PREREQUISITES: Primary Audience - Current or anticipated appointment as primary or secondary Unit Environmental Coordinator or equivalent. Coordinator of key environmental function within an organization. Secondary Audience - Supervisor of operations with environmental impact, ECAMP Evaluator, key environmental program manager, Bioenvironmental Engineer, Safety Officer, Judge Advocate. Duration: 3 Days. POC: Mr. Randall Schober @ 937-255-5654, extension 3535.

ENV 222 - Hazardous Material Management Program (HMMP)

OBJECTIVE: For each student to comprehend the objectives, principles, responsibilities and daily environmental, safety, and occupational health (ESOH) requirements of a Hazardous Material Pharmacy Program (HPP), and what it takes to communicate and orchestrate these requirements both within and outside their respective organization as part of the HAZMAT Management Process (HMMP) team. At the end of the course, students should have the knowledge to successfully plan, establish, and execute a HAZMAT Management Program. Students should be able to direct follow-up actions such as selling the program to senior leadership and programming for pharmacy requirements. DESCRIPTION: This course emphasizes pollution prevention concepts such as source reduction and reutilization within the overall management of HAZMAT. This course introduces management techniques for operating a sound HPP. Specific topics include the responsibilities of cross-functional team members comprising the HMMP and HPP; various laws, regulations, and forms affecting key HPP workers; the authorization and distribution processes of HAZMAT (i.e. overall inventory management; obtaining, receiving, and issuing HAZMAT; etc.); and the use of automated management information systems for managing and tracking HAZMAT. PREREQUISITES: Primary Audience - Current or anticipated appointment as a key HAZMAT Pharmacy worker to include anyone actively working in the HPP: Environmental Management, Logistics, Supply, Bioenvironmental Engineering, Safety, Procurement (buyers of HAZMAT), MAJCOM HPP Managers. Secondary Audience - Customers of the HPP Program (both input and output): Environmental Management Program Managers (CEV/EM) Hazardous Material Distribution Point Managers Quality Assurance Evaluators (QAEs) for HPP Contracts Maintenance, Unit Environmental Coordinators (UECs). Duration: 3 days. POC: Mr. Neal Hauschild @ 937-255-5654, extension 3537.

ENV 531 - Air Quality Management Course

OBJECTIVE: For each student to comprehend the technical and regulatory requirements of air quality management, and understand methods to plan, and implement successful comprehensive air quality management program at the installation level. DESCRIPTION: This course provides discussions of technical and regulatory issues appropriate for the installation-level air quality manager. Topics include compliance, emission inventories & processes, sampling & analysis,

permitting, pollution prevention and waste reduction strategy, control technology, aerospace NESHAPS, the conformity and risk management rules, and ODCs. A limited number of problem-solving exercises are included. Students and instructors are from all services.
PREREQUISITES: Primary Audience - Air Program Manager, ODC Program Manager. Secondary Audience - Environmental Flight Chief, Environmental Program Manager, MAJCOM Compliance Branch Chief. Grade: Commissioned officer, GS-7 or above. Education: Bachelor's degree in engineering, environmental science, or other closely related field. Duration: 1 Week. . **ISEERB approved for all DOD Components.
POC: Capt Brian George @ 937-255-5654, extension 3534.

Attending AFIT

Resident Quota Management/Enrollment Procedures: CESS Administration (CEA) will allocate quotas to MAJCOM training offices through the Training Management System (TMS) on a first-come basis to identified primary audience students by name. The MAJCOM training office sub-allocates its quotas with a training line number (TLN) to the appropriate base for students selected by CESS. The TLN is the authority for base MPF to publish travel orders. The base MPF enters the appropriate student information into the TMS NLT 21 days prior to course start date. This action allows adequate time for TMS data to flow through the system so class close-out can take place within 21 days of class start date.

Enrollment: USAF personnel must submit requests to their MAJCOM Training Manager (TM) using a DD Form 1556. If your MAJCOM does not require a DD Form 1556, applications must include the comparable information. MAJCOM TMs will send applications to AFIT/CEA on the date enrollment opens (which will be the first working day of each month for those classes starting three months in the future). The course directors will determine the eligibility of the applicant attending the course.

Non-Air Force DOD applicants should call AFIT/CEA, DSN 785-2156 or 937-255-2156, for application procedures.

Waiver Requests: Prerequisites are listed with each course description and identify the minimum level of academic and work experience required to fully participate in the program of instruction. Some courses require the student to be holding a specific job assignment. The maximum benefit accrues to those students who meet the established prerequisites. Supervisors, training personnel, and the MAJCOM TMs must closely screen the qualifications of the students they wish to send.

Applications: All enrollment requests must be approved at base and MAJCOM levels prior to forwarding to AFIT/CEA. The course director is the final approval authority on all applications.

Contractor Application Procedure: In accordance with AFCAT 36-2223, paragraph 1-52, "USAF Training for Contractor Personnel," employees of companies or corporations under contract to

the Armed Services may attend our resident or on-site education course offerings, on a "space available tuition pay" basis, if either of the following conditions apply: 1) the contract requires the government to provide training, or 2) the training required is not available from other sources and there is a material and direct benefit to the DOD. Please first contact Ms. Diane Osborne at commercial 937-255-5654, ext. 3588 to receive phone approval of the contractor's application package, on a "space available tuition pay" basis.

For more information on course offerings and enrollment, visit the CESS web site: http://cess.afit.af.mil

AFIT ENVIRONMENTAL COURSE OFFERINGS
FY 99
COURSE OFFERING START END DL* RESIDENT ENV020 Environmental Compliance Assessment 99A 19-Oct 23-Oct YES YES 99B 25-Jan 29-Jan YES 99C 15-Mar 19-Mar YES YES 99D 7-Jun 11-Jun YES ENV021 Intro to Installation Restoration Program 99A 4-Jan 8-Jan YES 99B 12-Apr 16-Apr YES 99C 14-Jun 18-Jun YES ENV022 Pollution Prevention Program Operations 99A 14-Dec 18-Dec YES and Management 99B 8-Feb 12-Feb YES YES 99C 19-Apr 23-Apr YES YES 99D 21-Jun 25-Jun YES ENV025 RACER 99A 26-Apr 27-Apr YES 99B 28-Jun 29-Jun YES ENV101 Intro to Environmental Management Flight 99A 8-Feb 19-Feb YES 99B 9-Aug 20-Aug YES ENV220 Unit Environmental Coordinator 99A 2-Nov 4-Nov YES 99B 19-Jan 21-Jan YES 99C 29-Mar 31-Mar YES 99D 17-May 19-May YES ENV222 Hazardous Material Management Program 99A 1-Dec 3-Dec YES 99B 20-Jan 22-Jan YES 99C 16-Mar 18-Mar YES 99D 18-May 20-May YES ENV416 Environmental Flight Commanders Course 99A 26-Oct 6-Nov YES ENV417 Environmental Restoration Project Mgt 99A 11-Jan 15-Jan YES 99B 19-Apr 23-Apr YES 99C 21-Jun 25-Jun YES ENV418 Environmental Contracting 99A 9-Nov 20-Nov YES 99B 3-May 14-May YES ENV419 Environmental Planning, Programming & 99A 8-Dec 10-Dec YES Budgeting 99B 13-Apr 15-Apr YES 99C 22-Jun 24-Jun YES FY 99 COURSE OFFERING START END DL* RESIDENT ENV521 Hazardous Waste 99A 19-Oct 23-Oct YES 99B 15-Feb 19-Feb YES 99C 17-May 21-May YES ENV531 Air Quality 99A 16-Nov 20-Nov YES 99B 22-Mar 26-May YES 99C 24-May 28-May YES FY 99 SEMINARS HAZWOPER Refresher (8 hours) 99A 6-Oct M, P YES 7-Oct E,C YES 99B 5-Jan M, P YES 6-Jan E,C YES 99C 13-Apr M, P YES 14-Apr E,C YES 99D 7-Jul M, P YES 8-Jul E,C YES Hazardous Waste Accumulation Site/ 99A 5-Nov M, P YES Initial Point Management (4 hours) 6-Nov E,C YES 99B 20-May M, P YES 21-May E,C YES Storm Water Management 99A 5 Nov M, P YES 6 Nov E, C YES 99B 20 May M, P YES 21 May E, C YES DL* = Distance Learning via Satellite M,P, E, C = Mountain, Pacific, Eastern, & Central Time Zones

SESSION III
P^2 INITIATIVES

SESSION CHAIRPERSONS:

Mr. David Stokes, HQ AETC/CEVQ
Mr. David Allen, KEVRIC Company, Inc.

ACHIEVING ENVIRONMENTAL EXCELLENCE THROUGH THE SOUTH CAROLINA/DEPARTMENT OF DEFENSE POLLUTION PREVENTION ALLIANCE

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INTRODUCTION

The South Carolina Environmental Excellence program and the South Carolina/Department of Defense Pollution Prevention Alliance represent a unique blending of two separate, but complementary programs. Administered by the Center for Environmental Policy at the University of South Carolina's Institute of Public Affairs, these programs share the goal of achieving environmental excellence through pollution prevention and resource conservation. The Environmental Excellence program is designed to reward and recognize entities that have voluntarily moved beyond regulatory compliance using pollution prevention, waste reduction, and resource conservation strategies. The Alliance is facilitating efforts by the state's military bases to attain formal recognition for their achievements through the Environmental Excellence program.

This paper presents an overview of the Environmental Excellence program and the Alliance. It describes how the Environmental Excellence program is being used to further the goals of the Alliance. To the extent that other states may be considering the creation of similar programs or the expansion of existing programs, some suggestions or "lessons learned" are offered. Since both programs are relatively new, the paper will conclude with a discussion of plans for future activities.

THE SOUTH CAROLINA ENVIRONMENTAL EXCELLENCE PROGRAM

In developing the Environmental Excellence program, South Carolina has followed a trend set by numerous states, EPA, and several industry trade organizations to create programs designed to encourage and reward entities that voluntarily implement environmental strategies to move beyond regulatory compliance. Generally, environmental recognition programs share several common characteristics. The central component is the use of pollution prevention to achieve environmental progress. A second element is a demonstration of commitment by senior management within the organization to ongoing waste reduction. Another component is formal recognition and program benefits that accrue for achieving environmental leadership status. Finally, most programs require some level of community outreach and public service.

Almost two years ago, a group of industry, environmental, and state agency leaders came together to discuss the possibility of creating an environmental recognition program for South Carolina. Discussions were initiated through the Institute of Public Affairs at the University of South Carolina and its Center for Environmental Policy. The Institute has been involved in a number of environmental initiatives for several years, including the administration of the Governor's Annual Pollution Prevention Award. Through its Center for Environmental Policy, the Institute also operates an industrial technical assistance program that works closely with the state's regulatory agency, the Department of Health and Environmental Control (DHEC), and its pollution prevention program.

A steering committee was formed to design the specifics of the program. Members represented a broad cross-section of interests and included the following: the State Chamber of Commerce; the S.C. Manufacturers Alliance; the S.C. Pulp and Paper Association; the Department of Natural Resources; DHEC; the State Energy office; the S.C. League of Women Voters; the S.C. Sierra Club; and the S.C. Wildlife Federation. An early decision was made by the steering committee to house the program within the Institute as a "neutral" third party. This decision was made, in part, because of concerns that businesses might be reluctant to participate in a program administered by the state's environmental regulators. For similar reasons, the steering committee avoided using the term "environmental leadership" in the program title because it did not want the state program to be confused with EPA's pilot program by the same name.

The overall objective of the Environmental Excellence program is to encourage entities to become environmental leaders through a demonstrated commitment to pollution prevention, and energy or other resource conservation. Membership applications include a statement which must be signed by senior management indicating a commitment to (1) reduce waste streams through pollution prevention and (2) share knowledge with others through the program. Applications may be submitted by either a "company" or a "facility." A company may apply on behalf of all of its plants in the state, or an individual plant may apply on its own. A "facility" is broadly defined to include not only a manufacturing plant but also a public or private non-manufacturing entity. This distinction is important for the Department of Defense Alliance because it allows military bases to apply for membership into the program.

In designing the program, the steering committee attempted to keep the application process as streamlined as possible. Industry members felt strongly that if an entity had already achieved superior environmental progress and been recognized for it, it should not have to go through a duplicative process for membership in the state program. This led to the creation of a two-tiered application process. First, an entity that is already an active member of a substantially similar program such as the American Textile Manufacturers Institute's Encouraging Environmental Excellence program or the Chemical Manufacturers Association's Responsible Care program, may submit documentation from that organization and request reciprocal membership in the state program. The second option is to submit an environmental excellence plan that includes measurable targets to reach waste reduction goals. The plan must also include a

commitment by senior management to establish a facility-wide environmental management system.

To maintain the integrity of the program, all applicants must describe their environmental compliance record over the past five years. Information concerning major violations, fines, and exceedances must be included. The concern is not for a single violation or an isolated incident, but rather for evidence of a pattern of enforcement issues that indicate a lack of commitment to continuous environmental improvement. The review committee may also request a site visit as part of the application process. This was a source of debate among the industry members some of whom felt strongly that for proprietary reasons and the highly competitive nature of some manufacturing sectors, requiring a site visit would serve as a disincentive to participate in the program. The compromise was to reserve the right of the committee to request a site visit in situations where there was some question about the applicant's environmental performance.

To be a meaningful program, clear benefits for participation were needed. Several steering committee members felt strongly that simply having another logo or awards program was not enough. They felt that the real benefit to being a member of the program should be the opportunity to have a "seat at the table" to share ideas with regulatory officials and other members, to serve as pilot sites when opportunities for regulatory flexibility arise, and to mentor other companies that may not be as environmentally progressive. DHEC's willingness to actively participate in the development of the regulatory incentives was instrumental in creating meaningful opportunities for the program's members. In fact, a crucial selling point for the military bases to participate in the Alliance and to work towards membership in the Environmental Excellence program was the opportunity to work with DHEC on regulatory flexibility issues.

THE SOUTH CAROLINA/DEPARTMENT OF DEFENSE P2 ALLIANCE

The South Carolina/Department of Defense Pollution Prevention Alliance ("Alliance") is patterned after the Texas Pollution Prevention Partnership. The Texas partnership includes state and federal regulatory agencies, the Department of Defense, the National Guard, the Coast Guard and the NASA-Johnson Space Center. It is designed to use pollution prevention as the preferred environmental alternative to enhance mission readiness and to integrate pollution prevention into the every day activities of military installations in Texas. The Air Force Center for Environmental Excellence was instrumental in developing the Texas partnership, and actively encouraged other states like South Carolina to initiate similar programs.

The process for establishing the Alliance in South Carolina began with a meeting of the regional environmental coordinators for the Army, Navy, Marines, and Air Force. Representatives from the National Guard also attended along with a representative from EPA Region 4 and the Air Force Center for Environmental Excellence. The meeting was co-hosted by the Center for Environmental Policy and DHEC's Center for Waste Minimization. The positive results of the initial meeting led to a second meeting with

representatives from all of the state's military bases. The regional environmental coordinators were instrumental in soliciting participation by the bases.

South Carolina has a strong military presence with each of the service branches having at least one installation in the state. The military bases represented at the second meeting included Charleston Air Force Base, Shaw Air Force Base, Fort Jackson Army Post, Charleston Naval Weapons Station, Marine Corps Air Station in Beaufort, Marine Corps Recruiting Station in Parris Island, McEntire Air National Guard, and the S.C. Army National Guard. At this meeting, interest in forming the Alliance was solidified, and discussions took place about the kinds of activities that would be most useful to the bases. The third meeting was hosted by Fort Jackson Army base. In addition to a half day tour of Fort Jackson's pollution prevention and recycling programs, the meeting included a more detailed presentation of the Environmental Excellence program and a review of the draft charter to formalize the Alliance. At this writing, the Alliance charter is being prepared for signature, and all of the state's military bases along with the S.C. National Guard have agreed to participate.

The overall goal of the Alliance is to implement pollution prevention strategies as the preferred environmental alternative to enhance mission readiness, to maintain and exceed compliance requirements, and to reduce the generation of pollutants. While the military bases have communicated in the past on environmental restoration and regulatory compliance issues through DHEC's federal facilities ombudsman, the Alliance provides a forum for the bases' pollution prevention coordinators to share information and exchange ideas as well as to actively interact with EPA and DHEC officials.

THE CONVERGENCE OF PROGRAM GOALS

The emphasis on pollution prevention and the commitment to moving beyond environmental compliance are the shared goals that join together the Alliance and the Environmental Excellence program. The military bases were interested in the Environmental Excellence program for several reasons. First, the program was compatible with the bases' pollution prevention goals and objectives. Second, the program offered an opportunity for individual bases to be formally recognized for their achievements in pollution prevention and waste reduction. Third, the bases were very interested in the possibility of serving as "test" sites for experiments with regulatory flexibility, and in working with DHEC and the EPA regional office on regulatory incentives for superior environmental performance.

For the Environmental Excellence program, allowing military bases to apply for membership was consistent with a longer range objective of the program to broaden its focus beyond the private manufacturing sector. In the past, several military bases have applied for and been awarded the Governor's Annual Pollution Prevention Award. The Environmental Excellence program was an opportunity to systematically encourage and recognize other bases that achieved successes in pollution prevention and waste reduction.

"LESSONS LEARNED"

For the Environmental Excellence Program

Even though the Environmental Excellence program is still relatively new (it was announced in October, 1997), some observations that suggest what worked in developing the program are apparent. First, it is critical to have a diversity of interests represented at the table. The Sierra Club representative often differed with the industry representative and the industry representative often differed with the DHEC official. But the end result was a balanced program that reflected the variety of perspectives brought to the table. The process for designing the program was consensus-based and, where there was disagreement, compromises were devised.

The diversity of interests represented in the design of the program also helped to strengthen the formal support base for the program once it was completed. All of the organizations that were represented on the steering committee became formal sponsors of the program. No organization walked away from the table and, in fact, two additional program sponsors specifically asked to be included after the fact. This broad base of support also created a network through which information about the program could be disseminated. Spreading the word about the program was time-consuming and slow initially, but the sponsoring organizations provided resources in the way of newsletters, speaking engagements and other avenues to promote the program.

Another critical element was the formal endorsement by DHEC. Having DHEC committed to working with Environmental Excellence members on regulatory and other issues was an important selling point for companies that might otherwise be reluctant to go through the application process. The committee sought, but failed to obtain, a similar endorsement from the Governor's office. While that office was kept informed of the deliberations and invited to participate, to date the Governor has not officially endorsed the program. As momentum for the program grows, it is anticipated that the Governor's office will become more involved.

From a programmatic standpoint, one of the key considerations was how to maintain the integrity of the membership through the selection process. There was strong sentiment against allowing companies into the program that were not in fact proven environmental leaders. One way the committee addressed this was in the screening of an applicant's past compliance record. A second way was in requiring the development of an environmental excellence plan. For entities applying for reciprocal membership, the committee carefully reviewed the programs to ensure that their goals and objectives were consistent with the state program.

For the Department of Defense Alliance

The Alliance was formed in a relatively short time span of less than a year. There are several reasons for this. First, the active involvement of the Air Force Center for Environmental Excellence at the outset lent credibility and focus to the effort. Second,

the early involvement and support of the regional environmental coordinators eased the way for the state's military bases to come together. Third, the already strong working partnership between DHEC's Center for Waste Minimization and USC's Center for Environmental Policy made it easier to join forces and work with one another. Specifically, DHEC's willingness to support the Alliance through its Center and by the active participation of its federal facilities ombudsman, strengthened the incentive for the military bases to come to the table. As a result, the Alliance meetings have served as a forum for asking questions about regulatory requirements and for raising issues that may be specific to an individual base. The presence of representatives from the EPA regional office also lent credibility and strength to the effort. And finally, the Alliance's decision to seek membership in the Environmental Excellence program gave the bases an additional incentive for achieving their pollution prevention goals.

CONCLUSION

As part of the continued development of the Alliance, a work group has been formed to work with staff for the Environmental Excellence program, to develop a standardized format for applications for membership into the program. Other work groups formed by the Alliance include a recycling work group to look at such issues as increasing recycling rates among the housing units on base, a regulatory work group charged with looking at the number and origin of regulatory requirements, and where opportunities for flexibility may exist; and a work group to explore "best management practices" in pollution prevention.

The Environmental Excellence program will continue to promote the program statewide and, through coordinated efforts between DHEC and the Center for Environmental Policy, continue to develop program activities for members. At this writing, an Environmental Excellence web page is being completed and a full-time coordinator is being hired. DHEC has arranged the first of several meetings with Environmental Excellence members to discuss issues of concern to them and to introduce state and local DHEC officials. This is an important first step in the ongoing development of relationships with DHEC officials and with other EEP members. Planned future activities include participation of Environmental Excellence members in the National Pollution Prevention Week in September, and site visits to formally present membership certificates.

The Environmental Excellence program and the Department of Defense Pollution Prevention Alliance are examples of the state's continued efforts to systematically promote pollution prevention as the preferred alternative and to reward facilities that achieve superior environmental performance through pollution prevention. Through the Alliance, the state's military bases can continue to work towards their pollution prevention goals. With the Environmental Excellence program, the bases have a unique opportunity to have their accomplishments showcased through membership in the program and, most importantly, to be recognized as environmental leaders in South Carolina and by their respective military commands.

Pollution Prevention in Shipboard Operations

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Introduction

The Pollution Prevention (P2) Afloat Program was established in 1995 to develop HM-related pollution prevention strategies for the U.S. Navy Fleet. Executive Order (EO) 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*, requires Federal agencies to comply with the planning and reporting provisions of the *Emergency Planning and Community Right-To-Know Act (EPCRA)*, and the *Pollution Prevention Act of 1990*. Part of Naval facility compliance is accomplished by setting goals for reducing the release of and off-site transfers of toxic chemicals for treatment and disposal by 50%, from a 1994 baseline. While Navy ships are not regarded as hazardous waste "generators" and are not required to comply with EO 12856, between 50 to 80% of hazardous waste reported by Navy homeport facilities is HM offloaded from ships. To support the shore facilities' reduction mandates, the P2 Afloat Program determines and implements HM source reduction initiatives, process or equipment changes, and recycling or reuse programs onboard ships.

The functionality and success of the P2 Afloat Program is derived from the participation of many Navy Commands and activities. The Chief of Naval Operations, Environmental Protection, Safety, and Occupational Health Division (CNO N45) provides program policy and oversight to the Program. NAVSEA 03L1 is the P2 Afloat Equipment Lifecycle Manager, providing technical engineering guidance and approval for Navy-wide implementation of P2 Afloat technology. NAVSEA 03R16 is the Research Development, Test and Evaluation (RDT&E) Program Manager and sponsors the test and evaluation of P2 Afloat equipment. The financial sponsorship of these codes, as well as funding received from Commander in Chief, Atlantic Fleet (CINCLANTFLT) Environmental Department (N465), via Naval Base Norfolk's Environmental Department, is vital to the successful testing of so many Opportunities on such a broad range of platforms.

CDNSWC Code 632 provides the technical leadership required to execute the Navy's P2 Afloat Program. They are the primary selectors of the waste streams to be targeted and the shipboard maintenance practices that can benefit from pollution prevention initiatives. They select the equipment to handle or eliminate the waste stream or process, and participate in ship checks, and equipment installation and implementation. Code 632 is also responsible for developing appropriate databases or spreadsheets, interim and final reports, and providing other technical support for the Program. CDNSWC Code 9152, as the Alteration Installation Team (AIT), has been the sole installing activity, and Naval Air Warfare Center, Lakehurst (NAWCADLKE) has been the primary procurement activity for the Program.

The information presented here provides the P2 Afloat Team's perspective on challenges encountered during the past three years, how the Team managed and corrected these issues; and the effects of the installed P2 Afloat equipment on shipboard operations. COTS products may not be the answer to all HM reduction issues but their direct shipboard applicability cannot be taken for granted. Applying common sense, low-level reengineering, and straightforward, realtime testing of COTS products are the keys to reduced installation time, operational costs, and the time allocated to accomplish standard maintenance. The most important lessons learned have been the recognition that even unsuccessful COTS products provide information to be applied to subsequent platforms. The Team recognizes that each ship is unique in design, mission and daily operational requirements, despite Class designation. Each ship requires analysis not only of the installed

engineering systems, but of the human operational and management practices in place onboard. The successful installation and application of any new equipment requires an understanding of standard and hull-specific shipboard operations. The P2 Afloat Team has augmented its knowledge of ships and environmental challenges by seeking out and attaining this understanding during all stages of a ship's involvement in the Program, and the test platforms and the Team members have profited experientially.

The P2 Afloat Program

In 1995, CDNSWC Code 632 was tasked to investigate and find solutions for excess/used HM issues aboard U.S. Navy ships. Five ships were selected as prototype platforms to represent major classes in the fleet: USS ANCHORAGE (LSD 36); USS JOHN HANCOCK (DDG 981); USS CARL VINSON (CVN 70); USS GEORGE WASHINGTON (CVN 73); and USS WASP (LHD 1). Later, five more ships were added, including: USS ARCTIC (AOE 8); USS KEARSARGE (LHD 3); USS YORKTOWN (CG 48); USS RUSHMORE (LSD 47) (in place of LSD 36); and SPRUCE BARGE (YFNX 42).

For each ship, the P2 Afloat Team examined offloaded excess/used HM records and then onboard pollution prevention practices that would provide the tools to reduce, recycle, or reuse HM. These practices are called "Opportunities" and include equipment, material, and/or process changes that minimize shipboard use, procurement, storage, handling, and offload of HM. Ultimately, Opportunities that pass shipboard testing and evaluation, based primarily on a positive ROI analysis, will be transitioned to the entire Fleet.

The P2 Afloat Team's focus is on the direct use or minimal reengineering of COTS products as the means to timely reduction of shipboard hazardous material use and its associated shoreside disposal impacts. This allows for cost savings derived from conducting T&E compared to a full research and development effort, and improves turnaround time for onboard installation. The equipment must be durable, user-friendly, have proper ship interfaces, and conform to the space available on any ship. The COTS approach places much confidence in an industry perhaps wholly unfamiliar with naval applications and encourages the surface Navy to realize that what works on shore may also be viable shipboard. This concept is the heart of the P2 Afloat Program and shipboard T&E has proved the validity of this approach.

Researching HM Use and Reduction Tools

Research includes regularly identifying used and excess HM offloaded from ships, conducting equipment searches, and performing ship checks to determine and alleviate the HM requirements. Any potential reengineering of selected COTS equipment for each installation must also be evaluated. For the P2 Afloat Program, the benefit of staggered installations has permitted lessons learned to be applied to successive ships and installations, and the testing phase has provided enough time to research and remedy problems while the prototype ships are still under the umbrella of the Program.

The best tools for identifying target waste streams are data logs from Naval shore facilities. The Norfolk Naval Base and Naval Station San Diego HM offload data reports supply quantitative breakdowns on ships' waste streams, listing all HM offloaded by ships—providing direct ties to our primary HM elimination and reduction targets. In addition, the homeport environmental personnel provide insight on which waste streams have high volume or cost concerns. Most P2 Opportunities are aimed at reducing the large amounts of paint, oily rag, and solvent wastes identified in the offload reports and by shore environmental personnel.

The P2 Afloat Team has also researched the HM used in periodic shipboard maintenance. As the Program matures and Opportunities transition, HM will be eliminated from shipboard use and the supply system,

During the test and evaluation phase, spares, consumables and technical literature for all P2 equipment have been provided at installation. During a six-month deployment, the Department owning the space or equipment may have to service the equipment and spare parts must be available, especially those most susceptible to failure with intense use over a short time. Belts, hoses, filters, and hose connections are likely to be damaged, misplaced, or expended by use. Anticipated failures must be supported while considering storage constraints on ships. The Program supports a prototype ship for 18 months, typically including a six-month deployment. User feedback has led to the development of a thorough and accurate spares and consumables list for all equipment, in the event a ship has to procure a repair part while deployed. After the deployment and return of five P2 ships and the examination of maintenance records, the P2 Team has been able to identify many of the parts that must be onboard and included in the final logistics package.

Copies of the manufacturer's technical literature are also provided to the ship's P2 Afloat point of contact and placed in the space with the associated P2 equipment. Recommended use and logistics data for spares are included in the data package. Sailors are encouraged to read the technical information, P2-specific requirements, and follow all provided instructions. For the six to 18 months following installation, this may be the only maintenance documentation available to ship's force. As the equipment being provided is new to the Navy, ship's force needs to take the initiative to read the manual carefully and become more familiar with the maintenance requirements for each piece of equipment. To alleviate this problem, the Program has always provided extensive training at the onset of the test and evaluation phase, and follow-on training, as requested.

Installation

Having an Alteration and Installation Team (AIT) that is familiar with the P2 Afloat objectives and equipment has decreased installation time by minimizing the learning curve. Because many of the AIT members have worked in or with the Navy for many years and are experts in Hull, Mechanical & Electrical (HM&E) systems and their associated maintenance requirements, their input regarding P2 installations is invaluable. As a fast-paced shipboard T&E program, new challenges are constantly encountered, whether with shipboard interfaces, equipment design, or any other number of issues, requiring flexibility and last minute changes. In addition, the AIT's oversight and input helps to ensure that all installation procedures meet the General Specifications for Shipbuilding and other legal requirements.

Many of the lessons learned are common sense for those who spend time aboard ships and others have come to light as a result of this non-traditional program. Installing equipment for the first time can affect the entire installation schedule if specialists have to work overtime to accommodate an unusual or unexpected requirement. To alleviate unexpected issues, equipment documentation is provided to the AIT before the installation. The installation team must have the time to review equipment requirements and perform a ship check to get an idea of what the installation involves. This also provides the installation team adequate time to select the right materials for the job, as well as time to prefabricate foundations.

Post-Installation T&E and ROI Analyses

The results of shipboard testing and evaluation are primary factors in determining whether any equipment is transitioned to the Fleet. From the inception of the Opportunity to this point, the P2 Afloat Team has been involved in research, procurement, and installation activities, but beyond installation the success of an Opportunity lies with ship's force. Currently, there are 27 Opportunities being tested and evaluated on six classes of Navy ships targeting a variety of ships' waste streams. These items are listed in Table 1. At the same time, new Opportunities are being tested, including Rechargeable Batteries, Reusable Oil Filters, and Low-Mercury Fluorescent Lamps.

Logsheets requesting information specific to an Opportunity are delivered with each piece of P2 equipment. Data including date of use, comments, and other information are recorded on the logsheets. An assessment of the baseline maintenance processes, as compared to an estimate of the time saved by the new process or tool, is also required. If spares are provided, a logsheet to record parts replacement data is included. During P2 equipment training, sailors are asked to log in the requested information, and the importance of the data is emphasized. Without accurate use and maintenance data, it is difficult, if not impossible, to quantify the effectiveness of the any equipment. As there are no standard PMS requirements associated with the equipment, data collection depends on individuals and the Commands now responsible for the equipment.

• Aqueous Parts Washers	• Backpack Vacuums	• Cable Cleaners & Lubricators
• Drum Crusher/In-Drum Compactors	• Mercury Ion Exchange Cartridge	• Thermoset Powder Coating System
• Glycol Recycler	• HVLP Paint Guns	• Hydraulic Fluid Purifier
• Maintenance-Free Batteries	• Explosion-Proof Vacuums	• Vortex Component Cooler Gun
• Paint Brush Holders	• Particle Counter System	• Paint Gun Cleaning Station
• Paint Tinting System	• Rag Recycling System	• Photoluminescent Labels
• Pressure Washer	• Paint Dispensers	• Hand Pumps & Spray Bottles
• Solvent Recycling Unit	• Flashpoint Tester	• Reciprocating Saw
• Vacuum Sanding Systems	• Wet/Dry Vacuums	• Paint Pens

TABLE 1. P2 Afloat Equipment

Specific and accurate usage data must be entered regularly for the logsheets to be useful. Typically, the more enthusiastic the ship is about the equipment, the better the response. Logsheet data for portable equipment, such as the Vacuum Cleaners, Reciprocating Saw, and Pressure Washers are often non-existent. Return on investment analyses for these pieces of equipment must rely on qualitative data based on user interviews and data reported verbally in place of specific logsheet data. In addition, it has been confirmed that sailors do not log data each time the equipment is used.

Usage data alone do not warrant or discount the effectiveness of any equipment. Reductions in manhours, maintenance periodicity, HM inventory, and improved quality of life are all viable components of the decision to transition any piece of P2 equipment to the Fleet. The east and west coast "Smart Ships" are both involved in the P2 Afloat initiative. Their goal of decreased manning concurs with a P2 Afloat Program goal to reduce the time spent on shipboard maintenance activities. Unfortunately, reduced manning onboard Smart Ships provides less time for ship's force to update logsheets. In these circumstances, qualitative data is weighed more heavily to supplement the lost value of logsheet data. To assist ship's force, automatic data systems (such as hour-counter meters on electric equipment) have been implemented.

Following the installation of the P2 suite of equipment and the subsequent deployment T&E phase, a final report providing the results and cost analyses of P2 initiatives tested and evaluated onboard is developed for each prototype ship. The report recommends transitioning Opportunities that are technically and economically feasible, and compatible with ship operations. Again, the initial decision for transitioning P2 equipment relies on data entered on logsheets during a ship's deployment. Misrepresentation of data input on the logsheets or neglecting to regularly log equipment use could mean the failure of a P2 Opportunity. However, there are Opportunities that the engineers and the P2 Team recognize as vital to the reduction of HM onboard, the improved safety of the sailor, and a reduced time applied to a maintenance process that

may not be reflected in a formal ROI. Engineering judgment and qualitative input from ship's force are often called upon to augment the decision to transition any P2 equipment or process.

Transitioning P2 Afloat Equipment

The ultimate product of the P2 Afloat Team's efforts will be the Fleet-wide transition of all equipment coming through the T&E phase with a favorable ROI. Opportunities whose initial ROI did not make the cut but may have great potential for preventing pollution were recommended for further test and evaluation. If an Opportunity shows negative cost savings, had a break-even point much greater than three years, or was not effective when compared to the baseline process, it is not recommended for transition.

Transition will be accomplished in two parts. A Jump-Start implementation phase will begin in FY99 and the actual Fleet-wide transition will commence in FY00 and continue through FY05. During Jump-Start, a group of ships from a variety of classes will receive 11 of the 23 pieces of equipment planned to be transitioned. Jump-Start will provide a final T&E opportunity for the P2 Afloat Team and the AIT to fill in any information, procurement, or engineering gaps prior to Transition. Ships represented in the Jump -Start and T&E phases will receive the balance of the equipment during the transition phase. The Transition phase will affect most ships of the current Fleet. The P2 Afloat Team is working in concert with the current ship acquisition programs, including LPD 17, DD 21, and CVX to ensure that the P2 Afloat equipment is provided if still required, based on new maintenance and inventory practices.

One of the most critical elements of the transition phases will be the completion of the formal logistics packages to support the P2 Afloat equipment. PMS documentation will be finalized during the early part of the transition period as well. Teams from CDNSWC Code 631 and NSWCCD-SSES Code 915 will be instrumental in the delivery of all of the requisite logistic information. In addition, Code 631 will represent the P2 Afloat Program as the equipment In-Service Engineering Agent.

Conclusion

Successful program implementation is and will continue to be a product of broadbased experience, shipboard test and evaluation, deckplate analysis, appropriate application of commercial products, and accurate assessment of transition targets. The P2 Afloat Program is an alternative to the traditional Navy approach of ship-specific research and development, and successfully brings together the effective handling of smaller budgets with the use of exceptional commercial industry products in the shipboard arena. Currently, 27 Opportunities are installed on six ships representing five ship classes. The P2 equipment suite will continuously be updated and evaluated during shipboard assessments, and equipment that proves effective and economically viable will be transitioned to the Fleet—bringing research to reality.

Authors

Rita Schuh is an environmental engineer and member of the Pollution Prevention Afloat Team. Previously, she was the Pollution Prevention Manager at Naval Station San Diego for both ashore and afloat hazardous and solid waste; the Hazardous Waste Manager at Misawa Air Base in Japan; and conducted Installation Restoration efforts at installations in the Naval Facilities Engineering Command, Chesapeake Division. Mrs. Schuh earned her BS in Mechanical Engineering from Ohio State University and her Masters in Public Administration from the University of Oklahoma.

Robin Hays began working at CDNSWC Code 632 as a member of the P2 Afloat Team in 1997. She has over ten years experience with naval environmental initiatives, engineering, and logistics in support of

NAVSEA, NAVSUP, and CNO codes. As a member of the P2 Afloat Team, Ms. Hays has managed P2 equipment installations and coordinated logistics requirements for P2 ships currently in the T&E phase. Her primary tasks in the P2 Afloat Program include participation in ship assessments, logistics coordination, outyear planning, and documentation development. She is also the Team's POC for new acquisition programs.

Life Cycle Engineering & Design Program

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ABSTRACT

During this decade, an increasing emphasis has been placed upon pollution prevention as a means to produce better products and systems while reducing environmental impacts from those systems. Several of the assessment tools and analytical techniques that have been used to do this, such as pollution prevention opportunity assessments, only look at on-site issues, ignoring impacts that might exist either upstream or downstream of the process. In order to capture these impacts, Life Cycle Assessment (LCA) was developed. LCA differs from other pollution prevention techniques in that it inventories all the resource, energy and cost inputs to a product, as well as the impacts from the associated waste streams, health and ecological burdens, and evaluates opportunities to improve the system on a life cycle scale.

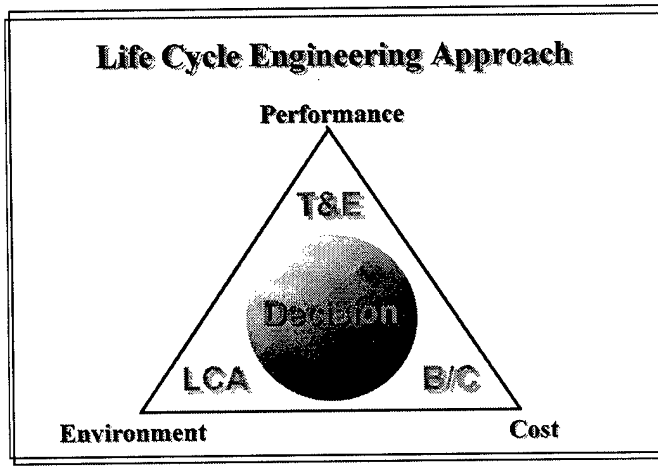
Co-sponsored by the Strategic Environmental Research & Development Program (SERDP) and EPA, the Life Cycle Engineering & Design (LCED) Program applies LCA methodology to DoD operations, systems, products and activities as a means to guide system design and aid life cycle decision-making. During the course of the LCED program, we have demonstrated that in some instances, a touted pollution prevention technology only transferred environmental burdens to another media or stage of the life cycle.

In order to illustrate the LCA methodology, case histories of three LCED projects will be presented: (1) Aircraft Radome Depainting; (2) Chemical Agent Resistant Coatings; (3) Energetic Materials for the GBU-24. Each project exhibits a distinct use of LCA methodology, which when applied to DoD operations is designed to unencumber military operations, enhance military systems' effectiveness, and improve the safety of personnel in meeting the Department's environmental obligations.

METHODOLOGY

Life Cycle Assessment, as EPA applies the term, consists of three overlapping analyses: Life Cycle Inventory (LCI); Impact Assessment (LCIA) and; Improvement Analysis (LCImA)[1]. However, the first step in every LCA is to set down the goals of the study and scope out the parameters. LCA is an expansive systems analysis methodology and the study must be carefully focused in order to acquire meaningful data. Therefore, the concept of LCA has goal definition and scoping as its center, a necessary first step before the analysis begins. The LCI is an inventory of resource, materials and energy consumed, as well as environmental releases produced for each stage in the life of a product, from raw material extraction to ultimate disposal (Note: EPA has published a manual for conducting LCIs[2]). After this information has been collected, an LCIA of the environmental and health effects related to resource consumption and environmental releases can be conducted. In fact, the LCIA begins to develop before the LCI is completed as impacts of priority concern are rapidly identified. The LCIA is both a quantitative and qualitative process to catagorize, characterize and value environmental impacts to form a basis for comparison between dissimilar impacts (e.g., global warming vs. ozone depletion). As the LCIA shapes up, the basis for the LCImA is formed, which identifies and provides an initial assessment of the changes needed to reduce environmental burdens of the product or process.

To the life cycle field, the LCED program brings the concept of balancing environmental concerns with requirements for operational performance and cost efficiency. Performance, Cost and Environment are the issues in determining the best solution in engineering and design of a product or process. That is to say, a failure in any of these key areas will have a direct negative impact the decision to proceed. Performance, Cost and Environment are also measured properly by inherently dissimilar metrics. For example, neither performance nor environment may be accurately measured in dollar signs. The diagram at right exhibits the concept of Life Cycle Engineering. The following discussion will show how this concept has been applied to three DoD operations.



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CHEMICAL AGENT RESISTANT COATING (CARC) LCA

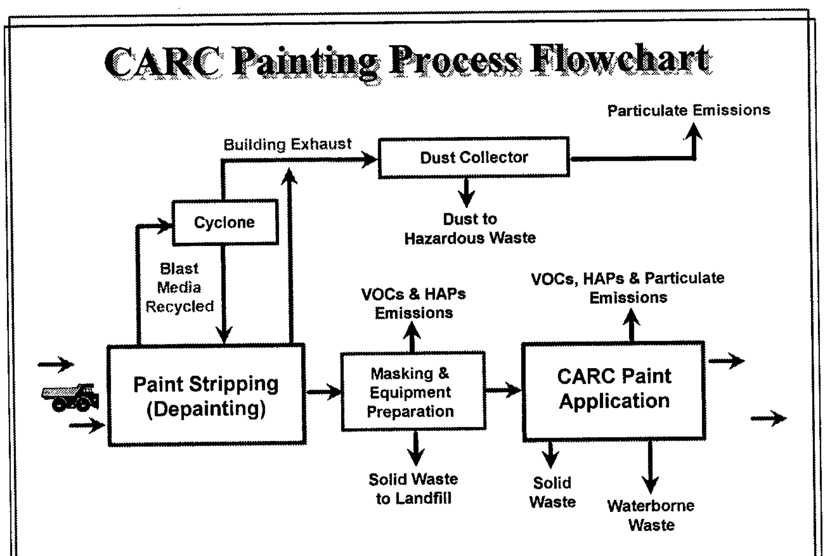
Two Army installations participated in the LCED study, and originally both had used Bink's Model 7 spray guns, but in accordance with recommendations from Pollution Prevention Opportunity Assessments (PPOA), had changed over to Mark 1 HVLP guns. Initially, this change led to better transfer efficiency, and the facilities saved up to $7,000 annually in reduced paint purchases. Over the longer term, however, problems cropped up. CARC is a much heavier, higher solids paint than found in commercial applications for which the HVLPs had been designed. Installations had problems with plugging, extended production times to deal with cleaning clogged equipment, and increased use of thinner.

Goal Definition and Scoping:

In this instance, the objective was to determine the combination of materials and equipment to paint CARC effectively at the lowest cost and minimal environmental impact. The CARC LCA was conducted for a baseline paint system, which included typical topcoat, thinner, and primer combinations determined from a survey of 13 major U.S. Army installations. The scoping survey was used to identify a typical CARC paint system, based on operations at Ft. Eustis, Virginia.

The Inventory (LCI):

The CARC LCI involved collection of environmental and utility data that describe the painting and depainting, and disposal of spent CARC and blast media, including the raw materials used, water and energy, air emissions, liquid wastes, and solid wastes. Where primary process information was missing, engineering estimates were made[3]. It was determined that the depainting and painting operations contributed greater than 80% of each of the following emissions from the total LCI: methyl isoamyl ketone, xylene, aromatic hydrocarbons, and



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National Risk Management Research Laboratory

hazardous solid wastes

The Impact Assessment (LCIA):

Since life cycle assessment is primarily about making comparisons and incorporating dissimilar impacts via the analysis, there has to be a methodology for making the comparisons on an equitable basis. An LCIA examines potential and actual environmental and human health effects from the use of resources (energy and materials) and environmental releases.[4] For CARC, nine impact categories were selected for characterization: smog formation, ozone depletion, acid rain, global warming, human health inhalation toxicity, terrestrial toxicity, aquatic toxicity, land use, and natural resource depletion. New impact equivalency units were created for some chemicals in the LCI, by using the hazard ranking approach described in an EPA report.[5] The valuation method used in this study is known as the Analytical Hierarchy Process (AHP).[6] Assignment of weights was done as a group exercise, where a four member team was asked to reach a consensus on the weight factors prior to their being entered into the model. Because the team included one cost engineer, one paints/coatings specialist, a civil engineer, and an ecologist, the valuation team mix, and the resulting weights, were considered reasonable.

The Improvement Assessment (LCImA):

On the basis of the LCIA, it was determined that the alternative with the best environmental potential included new spray equipment. The alternative spray equipment is the Can-am turbine HVLP, which uses turbine technology instead of the traditional method of passing compressed air through a conversion zone in order to convert high pressure, low volume air into HVLP. This technology decreases system turbulence which in turn reduces overspray significantly. The LCA found that a combination of an alternative primer, thinner and topcoat resulted in the lowest impact across the greatest number of impact categories, although it did not have the lowest impact for aquatic toxicity.

Performance Evaluation:

In order to test these conclusions, a technical evaluation was performed at two installations on test coupons and full-sized vehicles. The water-based primer performed well in moderate environments, but proved difficult to manage in high-humidity – although the painters felt confident that, given time to experiment further, they could use it efficiently. The evaluation supported the LCA's findings that cross-media impact of higher solvent usage by the HVLP guns over their predecessors would be eliminated by the new turbine-based HVLP systems. Further, the turbine HVLP dramatically improved transfer efficiencies, resulting in a 40% reduction in product use. Finally, the new system was well-received by the painters, who saw several benefits in terms of ease of cleanup and operations in the new systems.

Cost Assessment:

A life cycle cost assessment was conducted, comparing each alternative to the baseline system in place at Ft. Eustis. The assessment determined that, while the turbine-HVLP cost more than twice as much as the Mark 1 type HVLP system, the investment would be rapidly recovered in savings in product purchases. This alternative also exhibited a potential cost savings of $230,000 per year for each facility working at the Ft. Eustis level of painting operations.

Process Inconsistencies Between Sites:

The LCA showed that CARC paint is not consistently applied. In order to be able to force CARC topcoat through a typical HVLP gun, some facilities thinned it by as much as 20%, which dramatically increased VOC emissions. Two sites were using a lacquer thinner not approved for CARC. It seemed to perform better than the approved thinners in the painting process, but the installations had begun to notice a shortening of the life span of the CARC topcoat. Some installations would bypass the priming system entirely, using the CARC topcoat as a kind of "unicoat" material. Ironically, this practice substantially

reduced environmental impacts, but it is not yet known what long term performance, cost and environmental impacts may be created (e.g., changes in the endurance of the topcoat and the frequency of the painting cycles).

AIRCRAFT RADOME DEPAINTING LCA

The importance of the LCA approach in capturing upstream and downstream impacts can be demonstrated by an LCED project conducted for the Oklahoma City Air Logistics Center at Tinker AFB. OC-ALC painting personnel were looking for a drop-in replacement for methyl ethyl ketone (MEK) in the KC-135 radome depainting operation. OC-ALC depainted radomes in a shower of pure MEK, recycling the wash-off back into the system until it was removed as a sludge or vented off. This resulted in high VOC emissions and hazardous waste disposal costs.

Goal Definition and Scoping:

The scoping survey was brief, having only to identify the site specific aspects of the KC-135 radome depainting operations at the ALC. The objective was to develop a drop-in MEK replacement that would match or exceed performance and cost objectives, while eliminating the EPA-17 impact. This would allow the ALC to change over to a new depainting process without having to make a capital investment. Therefore, unlike the CARC example, this LCA would be used to develop an entirely new product and evaluate its potential. Unlike the CARC example, now the performance evaluation was conducted in concert with the LCI.

Performance Evaluation:

Our team proposed a solvent formulation, which we labeled PCB2, made up of propylene carbonate, n-methyl pyrrolidone (NMP), and dibasic esters (DBE) to eliminate MEK from the ALC operations without having to change equipment or procedures. The formulation was tested in lab scale to determine the best proportions of each chemical and then elevated to a coupon test. The PCB2 performed well on the coupons, which had been cut from condemned radomes, but while the performance was consistent with MEK, it was not superior. Tests were then conducted on two full-size radomes. One was depainted quickly and efficiently in comparable time to MEK, with no impact on the substrate. The second proved more difficult and took a ½ hour longer to complete. Painters informed the research team that this was not unusual performance for MEK, either, but there were insufficient funds available to depaint additional radomes to develop a more reliable statistical base.[7] However, both radomes were completely depainted, and there was no difficulty in repainting the radomes.

Cost Assessment:

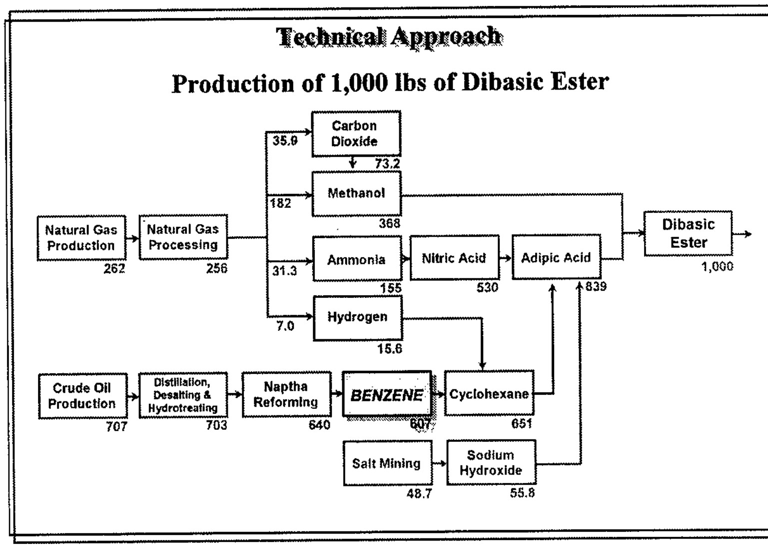
In this instance, a cost comparison with MEK was simplified by the fact that no equipment would have to be purchased and maintained. In the circumstance of direct purchase, use and disposal cost of PCB2 versus MEK, the PCB2 formulation offered a cost savings of $30,000 annually. This savings would occur without any effort to recover and recycle the PCB2 (again, the ALC was looking for a comparison of a drop-in replacement – recycling would require a capital investment for distillation equipment), which might increase the savings over the life cycle..

The Inventory (LCI):

The PCB2 LCI involved collection of environmental and utility data that describe the manufacturing of these chemicals and projected level of operations at the ALC, recycling of depleted solvent and disposal of spent solvent, including the raw materials used, water and energy, air emissions, liquid wastes, and solid wastes. The ALC was emitting methyl ethyl ketone (MEK), an EPA-17 chemical, from KC-135 radome depainting operations at the rate of almost 8,500 gallons annually.

The Impact Assessment (LCIA):

In this example, the ALC wishes to eliminate an EPA-17 chemical from the depainting operation, as a part of an overall plan to reduce the reliance of their systems on EPA-17 materials. Therefore, the value of an EPA-17 impact in the system amounts to a "no-go" decision. The LCI did identify that the DBE used in PCB2 had benzene as an upstream precursor[8]. Since benzene is on the same EPA list, proceeding with this change might appear to move the EPA-17 impact from the operations stage to the materials manufacture stage. In this case, the cost of the benzene might increase over time, raising the cost of the PCB2 formulation.



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However, upon closer examination of the DBE production process, it was shown that the benzene is derived in process from naptha and is 95% consumed in the production of cyclohexane (see diagram above). Therefore, benzene is not purchased as a product, but is produced in process and is ultimately consumed in a contained reaction.

GBU-24 ENERGETICS MODULE

The GBU-24 bomb is consists of several components, the largest of which is the BLU-109 bomb body. The energetic material is royal demolition explosive (RDX), which has been difficult and environmentally costly to remove and dispose of in the demil process. Several alternative materials, including trinitroazetidine (TNAZ) based energetics are being tested as potential replacements. In this instance DoD required a baseline inventory by which to evaluate the environmental impacts of alternatives

Goal Definition and Scoping:

The goal is to establish the baseline for RDX in the BLU-109 application, which can then be used for environmental analyses of alternative materials in support of future life cycle engineering evaluations. The scoping survey identified the processe specific to Holston and McAlester AAP operations for production of the energetic and assembly/demil with the BLU-109. This study differs from the previous cases in that it seeks to establish a baseline for future studies and to provide the framework to compare a mature product system (RDX) with prototype systems (TNAZ). Therefore, this effort establish the inventory of RDX and TNAZ for a basic comparison without a performance evaluation.

The Inventory (LCI):

There were significant issues in acquiring data which were resolved by using conservative methods to close gaps in process energy data for a TNAZ-filled BLU-109. When data was not available for a TNAZ process subcomponent, it was assumed that the TNAZ variant would be no worse than the RDX, pending a future performance evaluation. Further, an allowance was made for a statistical error of up to 20% before any conclusions were drawn as a measure to reduce uncertainty.

The Impact Assessment (LCIA):
The study was able to establish a reliable baseline for RDX and developed a trade-off assessment in relationship to TNAZ process operations. While the generation of non-listed waste was relatively the same between RDX and TNAZ, TNAZ production generated significantly higher levels of listed waste (e.g., regulated under CERCLA, RCRA, TSCA, TRI, etc.) by a factor of 19 to 1 in total weight. Point of origin of these wastes also sifted from commercial suppliers in the RDX life cycle, to DoD facilities in the TNAZ life cycle.

CONCLUSION

Applying LCA methodology to CARC resulted in a series of discoveries concerning upstream and downstream impacts, problems in the field not previously known to the designers, variances in procedures and potential improvements for the system. These issues came to light precisely because LCA is more than a gate-to-gate analysis and they raise several concerns that can impact the engineering and design processes. For example, while the change to HVLP guns did result in a decreased use of CARC paint via improved transfer efficiency, that impact was offset by an increase in organic solvent usage and VOC emissions. It is due to the fact that LCA is a systems-wide analysis, that it can identify and "flag" these situations.

Under the LCED program, a report entitled, "Lessons Learned in Life Cycle Engineering" has been developed and is available for comment. The document details the life cycle engineering approach and the lessons taught to us by experience. It includes a summary and outline of the final deliverable for this program, the "Life Cycle Engineering Guide." Both documents are being developed to specifically serve the DoD facility manager and the DoD program manager. Members of the DoD community are invited to review and comment upon the lessons learned document and proffer comments and criticisms for the engineering guide.

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Session IV
Obstacles to P² and How to Handle Them/P² in Hospitals

Session Chairpersons:

Mr. Stan Childs, Army Environmental Center
Mr. Kent Rohlof, SAIC

CAA-Mandated Emission Standards Effects on Medical Waste Incinerators

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Abstract:

New emission standards (Federal Register, 1997) for hospital/medical/infectious waste/ incinerators (HMIWIs) require reduced emissions of pollutants. This paper addresses technical challenges and provides a discussion of possible alternatives available to medical waste managers at DoD facilities. Waste minimization, improvements to existing incinerators, permit requirements, and relative costs are presented. In addition alternative technologies such as steam reforming are discussed.

EPA estimates that there are 2,400 existing HMIWIs. Initially EPA estimated that the proposed rule would cause 80% of existing incinerators to be shutdown. The June 1996 notice (Federal Register, 1996) presents revised impacts but does not provide a revised estimate of the number of HMIWIs that might be shutdown. The HMIWI regulations are based on the Clean Air Act Amendments of 1990 specifically requiring EPA to promulgate emission standards. The incinerator standards are based on maximum achievable control technology (MACT).

EPA requires that waste management plans identify pollution prevention measures for eliminating sources of pollutants through waste minimization and segregation. Necessary improvements to existing incinerators will vary depending on size and efficiency. Good combustion controls will be mandatory. In addition treatment of the off-gas using scrubbers and/or activated carbon adsorption may be needed. Retrofitting of older inefficient units may be too expensive compared to off-site disposal, replacement, or implementation of new technologies.

Background

In February 1995, EPA proposed new source performance standards (NSPS) based on several years of review of performance data on HMIWIs (Federal Register, 1995). These standards were

based on incinerator design differences—namely batch, intermittent, and continuous, and on results of studies of wet scrubber and dry scrubber treatment and controls of off-gas as compared to no controls. In June 1996, EPA published a re-proposal to announce availability of information and provide guidance on the potential changes to the standards (Federal Register, 1996). One of the changes was to re-categorize HMIWIs based on capacity; small (200 pounds per hour [lb/hr]), medium (201 to 500 lb/hr), and large (greater than 500 lb/hr). In addition, EPA excluded crematories and incinerators used solely for burning pathological waste, "off-spec" drugs or pharmaceuticals, and radioactive medical wastes. In the final rules (Federal Register, 1997) EPA provided for pollution prevention and waste minimization, excluded co-combustors and cement kilns, and added requirements for testing, monitoring and inspection, and operator training and qualification.

The NSPS implements sections 111 and 129 of the Clean Air Act (CAA) as amended in 1990. These standards apply to incinerators that combust any medical/infectious waste generated in the diagnosis, treatment, or immunization of human beings or animals, or in the production or testing of biologicals. Regulated entities include public and private hospitals, medical clinics, research laboratories, waste disposal companies, and health care facilities.

EPA estimates cost impacts of the MACT standards for new HMIWI to hospitals, nursing homes, etc. (Federal Register, 1997) are in the range of 0.00 to 0.16 percent of total operating costs. This translates to less than 35 cents per-patient day. Impacts to existing on-site facilities range from 0.03 to 1.70 percent of total costs. Waste minimization and total chemicals management has the potential to substantially reduce costs or provide savings in comparison to existing practices.

Regulatory

Existing sources are required to achieve MACT (lower average emissions of lowest 12% of HMIWI in category). New sources must achieve emissions control equal to the best-controlled similar unit. Table 1 is a summary of emission limits for existing and new incinerators. Small HMIWI emission limits are less stringent than medium and large units for particulate matter, dioxins, hydrogen chloride, lead, and cadmium. Existing unit emission limits are less stringent than new units for particulate matter and hydrogen chloride.

Table 2 is a summary of additional requirements, including operator training and qualifications, information and records, siting analysis, performance testing, and waste management plans.

Schedule

All new HMIWI that began construction after 20 June 1996 or existing HMIWI that began modification after 16 March 1998, are currently required to meet the federal requirements contained under subpart Ec. Existing HMIWI constructed on or before 20 June 1996 are subject to section 111(d)/129 State regulatory plans under subpart Ce (Federal Register, 1997). Table 3 is a compliance schedule. Given these time frames, it is imperative that HMIWI managers begin

evaluation and planning to avoid notice of violations for non-compliance or excessive expense for expediting improvements or contracting off-site disposal.

Waste Minimization

Reducing the volumes and toxic nature of infectious solid wastes has the potential to save money and bring existing incinerators into compliance with the new guidelines. Before making any decisions to implement new equipment or controls technologies, one must evaluate waste minimization and pollution prevention practices. It is estimated that hospitals generate approximately 1 percent of all municipal solid waste generated in the United States (AHA, 1993). Approximately 2 million tons are shipped to landfills or incinerated annually, 15 percent of which is classified as infectious waste requiring special handling. Mt. Sinai Medical Center, NY, a 1100+ bed hospital, medical school, and research facility saved over $1 million per year through implementation of a waste segregation program that went into effect in June 1989 (Bisson et al, 1993). This savings was realized largely through training of nurses and housekeepers and removal of red-bags from patient rooms.

Conducting a waste audit can identify problem areas and provide information for formulating a strategy. Determine the flow of materials from the point they enter the premises to their ultimate disposal. Look for opportunities to segregate infectious from municipal waste. Question the need for packaging and other materials. Next develop a strategy, set goals, train personnel, and implement and track progress. Chemicals management may also profoundly affect overall success in meeting emissions guidelines. Elimination of toxics such as lead, mercury, cadmium, and halogenated compounds can often lead to considerable savings and assure compliance. Sources include:
Trace metals—surgical blades, foil wrappers, plastics and inks;
Hydrochloric acid—PVC plastic bags and containers;
Mercury—dental supplies and batteries; and
Cadmium—PVC plastic bags.

An understanding of the flow and function of chemicals and the effect on incinerator performance can often lead to identification and subsequent elimination of the source.

If internal resources are not available, consider retaining qualified professionals who are experts in creating and implementing an integrated waste minimization and chemical management program and can provide a full range of services including testing, evaluation, and implementation of any necessary incinerator controls.

Evaluation

Once waste minimization effects are identified, it is time to evaluate their effect on HMIWIs. First, determine if your waste falls under the following exclusions:

Waste is entirely pathological, chemotherapeutic, low level radioactive;
Hospital waste constitutes less than 10% by weight of total being incinerated;

Waste is being used as a fuel in a cement kiln;
HMIWI is alternately being used for medical waste and municipal waste; or
Reductions of pollutants as shown in Table 1.

If the waste is not excluded, then a material balance should be prepared and a model developed to predict estimated emissions, operating range, air flows, and life cycle costs. A preliminary assessment can often be made to determine whether to continue operation, provide additional controls, or contract with an off-site treatment facility. A preliminary emissions test should then be conducted to verify/calibrate the model. Several different flow rates and temperature and air rates are recommended to determine optimum operating ranges. The model will serve as an invaluable tool in troubleshooting and projecting the effects of future changes on incinerator performance and ability to meet future compliance requirements.

Performance

Medical waste incinerators are by their nature complex and prone to upsets when improperly operated. The HMIWI is designed to reduce overall volume, destroy microorganisms, and combust organic material. Incinerator performance is a direct function of time, turbulence, temperature (the three "Ts"), waste composition, air flow, and moisture content of waste. In general, the longer the residence time, the greater the mixing and the higher the temperature, the better the destruction efficiency and volume reduction of organic waste. Most HMIWIs in operation are based on "starved air" technology. Waste is fed into a primary chamber where it is heated to between 1,400 and 1,800 (F. Air is added at 40 to 70 percent of stoichiometric to sterilize, dry, and pyrolize volatiles while minimizing ash particulate carryover into the second chamber. In the second chamber air is added at a controlled rate of 100 to 140 percent of stoichiometric and temperatures and residence time of greater than 1,800 (F and 1 second are maintained to assure combustion of volatile organic compounds and minimize formation of dioxin and furan compounds. Air velocity is typically maintained between 4 and 15 feet per second and often is added tangentially to provide a swirling air pattern to increase mixing and turbulence. The majority of the ash is removed from the primary chamber. Medical waste contains varying amounts of glass, silica, metals, and ceramics that are not oxidized and can cause formation of slag and eventually foul the combustion chamber surface if the temperature exceeds 1,800 (F.

Controls

Many incinerators will not meet the new NSPS requirements and, therefore, will require additional HMIWI air and temperature combustion and flue-gas controls if they are to remain in service. Air and temperature controls may have to be modified to allow optimum operation. Due to the variability of medical waste, the air and supplemental fuel rate and subsequent combustion efficiency can change dramatically if good continuous controls are not provided. Too little air will result in incomplete combustion and the possible formation of dioxins and furan and release of bacteria to the atmosphere. Too much air can cause carryover of particulate, reduce combustion temperature, and increase fuel use. Often the cost of tuning and addition of controls provide good return on investment with payback of capital within one year.

Flue gas controls should only be added after the effects of tuning and improvement of controls are known. Options include wet scrubber, dry scrubber with lime addition, and baghouse. Small HMIWIs will likely require venturi wet scrubbers; medium HMIWIs, a combination of dry scrubbers with lime injection, baghouse and wet scrubbing; large HMIWIs, baghouse and packed tower or sub-cooled venturi/packed tower scrubbing and most likely carbon injection (Van Remmen, 1998). Costs are estimated to range from $150,000 to $250,000 for small HMIWIs and $300,000 to $500,000 for medium and large units.

Alternatives

Alternatives to operation of on-site HMIWIs may be more cost effective and environmentally friendly. These include:
Reclassify as pathological waste, radiological waste, or pharmaceutical;
Contract off-site disposal in a permitted treatment storage and disposal facility;
Co-combust with coal;
Provide as fuel in a cement kiln; and
Use alternate technologies for sterilization and disposal.

If the HMIWI is being used exclusively for pathological, radiological, or pharmaceutical waste, it is excluded from the new guidelines.

The cost of improvements (especially older units) may not be cost effective as compared to contracting with a waste hauler that is capable of incinerating the material off site in an EPA permitted TSD facility.

If a power plant or cement kiln is in the area, the potential exists that they can use the waste as a fuel.

Other technologies may be more cost effective than incineration. Following are a number of technologies for consideration:

Steam Sterilization—autoclave sterilization at a temperature of at least 275(F temperature to kill bacteria, followed by grinding and combination with other wastes to make it indistinguishable when disposed of at a municipal landfill;
Steam Reforming—destruction and volume reduction using high temperature steam at 1,200 (F;
Pyrolysis—heat to above 600(F in the absence of air to drive volatiles off followed by combustion as a fuel at greater than 1,800(F;
Vitrification—heat to 3,000(F using plasma or other means in a chamber without air to form gases and molten glass;
Infrared—use of far infrared rays to kill micro organisms followed by shredding and disposal at landfill; and
Microwave—shredding of material followed by steam and microwave treatment.

A life cycle cost assessment should be conducted prior to selection of the final remedy.

Summary

The new NSPS for HMIWIs will require careful planning and evaluation to avoid penalties for non-compliance. Managers responsible at DoD hospitals and medical facilities will need to become familiar with the new regulations and determine if their HMIWIs are excluded, whether additional controls are needed, or whether they should be shutdown and waste disposal be contracted through a waste hauler with permitted TSD facilities. Waste minimization of infectious waste can provide excellent value and has potential to bring existing HMIWIs into compliance. To be successful it is important to get an early start in funding, planning, and evaluation at hospitals and medical facilities.

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Table 1. Emission Levels Established for HWI Units Under 40 CFR 60 Subpart Ce and Ec

Pollutant
(Test Method) Small HMI Medium HMI Large HMI
New Existing
Rural Existing
Urban
New
Existing
New
Existing Particulate Matter (gr/dscf)
(EPA Method 5 or Method 29) 0.03 0.086 0.05 0.015 0.03 0.015 0.015 Carbon Monoxide
(ppmv)
(EPA Method 10 or Method 10B) 40 40 40 40 40 40 40 Dioxins/Furans (ng/dscf)
(EPA Method 23) 125
800 125 25 125 25 125 Hydrogen Chloride (ppmv) (EPA Method 26) 15
or 99%
reduction 3,100
100
or 93%
reduction 15
or 99%
reduction 100
or 93%
reduction 15
or 99%
reduction 100
or 93%
reduction Sulfur Dioxide (ppmv)
(testing not required) 55 55 55 55 55 55 55 Nitrogen Oxides (ppmv)
(testing not required 250 250 250 250 250 250 250 Lead (mg/dscm) (EPA Method 29) 1.2
or 70%
reduction 10 1.2
or 70%
reduction 0.07
or 98%
reduction 1.2
or 70%
reduction 0.07
or 98%
reduction 1.2
or 70%
reduction Cadmium (mg/dcsm)
(EPA Method 29) 0.16
or 65%

reduction 4 0.16
or 65%
reduction 0.04
0.16
or 65%
reduction 0.04 0.16
or 65%
reduction Mercury (mg/dcsm)
(EPA Method 29) 0.55
or 85%
reduction 7.5 0.55
or 85%
reduction 0.55
or 85%
reduction 0.55
or 85%
reduction 0.55
or 85%
reduction 0.55
or 85%
reduction Source: 40 CFR 60 Subpart Ce and Ec.

Table 2. Summary of Additional Requirements Under the Emission Guidelines
Additional Requirements

Operator Training and Qualifications Requirements:
Complete HWI operator training course,
Qualify operators,
Maintain information regarding HWI operating procedures and review annually.
Inspection Requirements:
Provide for an annual equipment inspection of the designated facility.
Waste Management Plan:
Prepare a waste management plan that identifies the feasibility and approach to separate certain components of a health care waste stream.
Compliance and Performance Testing Requirements:
Conduct an initial performance test to determine compliance with the PM, CO, CDD/CDF, HCl, Pb, Cd, and Hg emissions limits and opacity limit, and establish operating parameters.
Conduct annual performance tests to determine compliance with the PM, CO, and HCl emission limits and opacity limit.

Table 2. (Continued)
Additional Requirements Facilities may conduct performance tests for PM, CO, and HCl every third year if the previous three HWI performance tests demonstrate that the facility is in compliance with the emission limits for PM, CO, or HCl.
Perform annual fugitive testing (large, new HWI).
Monitoring Requirements:
Install and maintain equipment to continuously monitor operating parameters including secondary chamber temperature, waste feed rate, bypass stack, and APCD operating parameters as appropriate.
Obtain monitoring data at all times during HWI operation.
Reporting and Record Keeping Requirements:
Maintain for 5 years records of results from initial performance test and all subsequent performance tests, operating parameters, any maintenance, the siting analysis, and operator training and qualification.
Submit the results of the initial performance test and all subsequent performance tests.
Submit reports on emission rates or operating parameters that have not been recorded or that exceeded applicable limits.
Provide notification of intent to construct, construction commencement date, planned initial start-up date, planned waste type(s) to be combusted, the waste management plan, and documentation resulting from the siting analysis for new HMIWI. Note: This table depicts major provisions of the NSPS. Refer to final guideline Subpart Ce and Ec for complete requirements.

Table 3. Compliance Schedule:
Requirement New HMIWI Existing HMIWI* Effective Date 20 June 1996 September 15, 1998 Operator training & qualifications Initial startup Within one year of approval of State plan Inspection requirements Within one year of approval of State plan Initial compliance test 180 day from initial startup Within one year of approval of State plan or up to 3 years after EPA approval of State plan if the source is granted an extension. Performance test Within 12 months of initial compliance test and annually thereafter. Every third year if the three previous annual tests demonstrate compliance Within 12 months following initial compliance test and

annually thereafter Parameter monitoring Continuous Continuous Record keeping Continuous Continuous Reporting Annually, semiannually if not compliant Annually, upon completion of initial compliance test; semiannually, if not compliant *Note: State plans for existing HMIWIs are due September 15, 1998. The Federal EPA is required to approve or disapprove these plans within 6 months. If a plan is disapproved, reasons are published in the Federal Register and the State can submit a revised plan. If the plan is not approved on or before September 15, 1999, Federal EPA will implement a plan.

Pollution Prevention in an Era of Regionalization

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The Navy in San Diego is going through a process of centralizing environmental programs. As a result, pollution prevention must be managed with fewer resources. Although this may be a challenge, it will provide opportunities to improve pollution prevention throughout San Diego, and for the Navy as a whole.

Like environmental compliance, pollution prevention must be an integral part of everyday operations. Its concepts are the inherent responsibility of every media-specific compliance program (such as air, water, and hazardous waste). The San Diego Regionalization Team has chosen to include pollution prevention responsibilities in the position description of each media-specific program manager, and to establish a Pollution Prevention Manager position to coordinate efforts across all media. This coordinator will act as a "champion" of pollution prevention throughout the San Diego region. He/she will coordinate projects, provide advice and resources to program managers, and interface with both the Navy and San Diego pollution prevention communities. In addition, the coordinator will obtain funding and spearhead technology transfer for local pollution prevention efforts. These duties will be supported by additional personnel, including a New Environmental Initiatives Program Manager, a Community Relations Coordinator, and a Training Program Manager.

Communication is essential for the Pollution Prevention Program to ensure that all commands are aware of changes in policy and requirements, as well as new technologies and resources. Within the structure of a regional command, a central Pollution Prevention Manager can facilitate communication and provide consistency, which is

currently difficult to achieve since Navy commands place varying amounts of emphasis on pollution prevention. By remaining abreast of current developments, facilitating communication, and staying in touch with day-to-day operations, this new environmental organization can strengthen the Navy's pollution prevention program.

TRADITION OF EXCELLENCE

AmDyne® Corporation

HAZARDOUS MATERIAL MINIMIZATION EFFORTS in PAINTS and COATINGS U.S. ARMY AVIATION and MISSILE COMMAND

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U.S. ARMY AMCOM ENVIRONMENTAL TECHNOLOGY TEAM

AMCOM Effort

AmDyne® Corporation

- Identify Applicable Aviation and Missile Command (AMCOM) missile system maintenance documentation
- Review documentation by system
- Subdivide identified HMs by functional class and application
- Develop and populate databases
- Evaluate each identified use of material in the weapon system

Data Evaluation Process

AmDyne® Corporation

- Identify pre- and post maintenance processes
- Identify substrate composition
- Identify alternative materials
  - Commercial resources
  - Inter and Intra-service research efforts
- Evaluate proposed substitutes
- Recommend and coordinate proposed changes through all approving parties

Identification of Materials

AmDyne® Corporation

- Technical Data Package / Maintenance Document Information typically include:
  - Specification data, National Stock Number (NSN) & product name or generic nomenclature
- Obtain complete MSDS data
  - Search HM Information System (HMIS)
  - Search FED-LOG for supplier data
  - Contact supplier(s) for up-to-date MSDS information for each product
- Communicate with maintenance depots to identify what they are currently using

PATRIOT - Paints/Coatings, Varnishes & CPCs

AmDyne® Corporation

- ☆ 593 initial entries for paints/coatings, varnishes & Corrosion Prevention Compounds
  - Additional requirements identified from TDP drawings
- ☆ 5 Missile Interim Specifications (MIS)
- ☆ 25 Military Specifications, 1 Commercial Item Description
- ☆ 107 primary or alternate NSN

Hazardous Material Breakdown

AmDyne® Corporation

- **Hazardous Solvents**
  - Hazardous Air Pollutants / Air Contaminants (HAPs / HACs)
  - Volatile Organic Compound (VOC) content
    - Toluene and/or Xylene
    - Methyl Ethyl Ketone and/or Methyl Isobutyl Ketone (MEK/MIBK)
- **Hazardous Metals**
  - Chromium, Cadmium, Cobalt, Lead, Beryllium

Hazardous Material Breakdown

(continued)

AmDyne® Corporation

☆ RCRA Characteristics

- Flashpoint
- pH
- Disposal requirements

☆ OSHA - Issues

- Severe reduction in exposure levels for chromium and cadmium
- Additional safety and health and personal protective equipment (PPE) requirements for continued use

Patriot Coating Materials

AmDyne® Corporation

- ☆ Conversion Coatings
- ☆ Pre-primers
- ☆ Primers
- ☆ Topcoat

Chromate Conversion Coating (CCC)

AmDyne® Corporation

- MIL-C-5541 Class 1A or 3: Conversion Coating
  - Hexavalent chromium primary constituent
  - Used on all aluminum components
- Alternative Process for Aluminum Armored Vehicles
  - Test program coordinated by TACOM - anticipated completion Sep 99
  - Developed and tested at Red River Army Depot
    - Profile surface - 2-4 mil with garnet blast & Prime
    - Approved for Bradley Family of Vehicles

Acid Wash Pre-Primer

AmDyne® Corporation

- DoD-P-15328: Acid Wash Pre-Primer Specification
  - Contains phosphoric acid and chromates,
    - 2-component, solvent based
  - Low pH and low flashpoint
- 3 alternatives under test at the Army Research Lab (ARL)
  - Compatibility with current primers & topcoats
- Other non-traditional coating systems
  - Polyanilines and Sol-Gels

AmDyne® Corporation

Primers

- 3 Specifications
  - MIL-P-23377: high VOC, solvent based, chromates
  - MIL-P-53022: low VOC solvent based, no chromates
    - Used at depots in place of MIL-P-23377
  - MIL-P-53030: water reducible, no chromates
- Ultimately the selection of which primer to use is up to Project Office

Chemical Agent Resistant Coating (CARC)

AmDyne® Corporation

- 3 specifications
  - MIL-C-46168: 2-component , solvent based, high VOC
  - MIL-C-53039: single component, solvent based, lower VOC
  - MIL-P-64159: water-reducible, new specification
- Ultimately the selection of which CARC to use is up to Project Office
  - MIL-P-64159 will be an option on Bradley
- Efforts underway to test and approve powder coat CARC for interior surfaces

EPCRA's New Guidance: Impacts on DoD Reporting and Targets

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Overview

Department of Defense (DoD) installations have reporting responsibilities under the Emergency Planning and Community Right-to-Know Act (EPCRA), as well as a mandate to reduce reportable releases by the end of 1999. While DoD has been implementing approaches to meet EPCRA's complex threshold and reporting requirements, EPA has made significant changes to the regulated chemicals, thresholds, and guidance.

This paper summarizes EPCRA developments through June 1998 for their impact on DoD compliance, with particular focus on the expanded thresholds and recent guidance, including:

- Potential impacts of EPA's proposed revisions to Section 311 and 312 reporting for gasoline and diesel fuel.
- Effects of EPA's expanded definition for the EPCRA Section 313 "Otherwise Use" threshold.
- EPA's recent guidance, including the revised Section 313 Question & Answer document, and guidance developed for the newly added industries.
- New interpretations and policies for reporting sulfuric acid aerosols, ammonia in wastewater treatment plants, and nitrate compounds.
- Recent developments in other environmental programs, such as the Clean Air Act Amendment Risk Management Plan requirements, which overlap with EPCRA.
- Continued efforts to expand Section 313 reporting to include toxic chemical use information.

The paper concludes with considerations for the importance of managing on-going EPCRA developments and maintaining compliance.

Overview of EPCRA Requirements and Recent Changes

U.S. Department of Defense installations are covered by the Emergency Planning and Community Right-to-Know Act (EPCRA) due to Executive Order 12856, which was signed by President Clinton on 3 August 1993. EO 12856 applied EPCRA requirements to federal facilities and waived the SIC code criterion for reporting under section 313. All other provisions of EPCRA and the PPA apply to military facilities as to industrial operations.

EPCRA requires that the chemicals and mixtures present on-site, and involved in particular types of activities, be evaluated against five types of EPCRA reporting: emergency planning, release notification, identity and composition of mixtures, inventory, and annual TRI releases.

EPCRA Emergency Planning Requirements (Sections 301-303) are designed to improve community-wide emergency response and preparedness through coordination and planning at the local and state levels. DoD installations are required to notify the State Emergency Response Commission (SERC) and Local Emergency Planning Committee (LEPC) about the identity and amounts of EHSs present in quantities above the threshold planning quantities (TPQ). The information must be updated to reflect "any changes occurring at the facility which may be relevant to emergency planning."

Although EPA has not revised the EPCRA Section 301-303 requirements that apply to DoD facilities, other programs, such as the Clean Air Act Risk Management Plan requirements (as described below) must be factored into overall installation-wide emergency planning.

Emergency Notification (Section 304) requires DoD installations to notify all affected LEPCs and SERCs about chemical releases beyond the facility boundary in 24 hours, if the release exceeded the reportable quantity (RQ) limit for any extremely hazardous substance (EHS), or CERCLA section 102(a) substance. Immediate notification is required, with written follow-up to describe the spill and response actions taken.

Recent revisions to the Section 304 chemical lists that must be covered by DoD installations' emergency release reporting include:

- EPA added 58 chemicals to the RCRA Subtitle C hazardous waste list in February 1995, a change that became effective July 12, 1995. Those materials were also added to the CERCLA hazardous substance list by reference, and therefore, became covered under EPCRA section 304 reporting. (60 FR 7825; edits 60 FR 19165 and 25619)

- EPA revised the RQs of 47 hazardous air pollutants, 5 Clean Air Act Categories, and 11 RCRA wastes or proposed wastes on June 12, 1995 (60 FR 30926). The changes become effective July 12, 1995 and affect RQ's of seven Extremely Hazardous Substances. The RQ of ethylene glycol was set to 5,000 pounds.

Community Right-to-Know (Sections 311-312) requires facilities to report on amounts and hazards of the mixtures and chemicals present on-site in excess of specific limits. Reports are required in the form of: MSDSs or a list of MSDSs (under Section 311), and an annual Tier II inventory of chemicals (under Section 312). Reports are submitted to LEPCs, SERCs, and fire departments.

On 8 June 1998, EPA proposed to revised the reporting requirements for EPCRA section 311 and 312 reporting (63 FR 31268-31317). Although these changes are not yet final, the impact on DoD installation's Tier II reports next March may be very significant if the rule is finalized during 1998, as EPA is predicting. Specific issues in the proposed revisions include:

- Raising the threshold for gasoline to 75,000 gallons for the combined amount of all gasoline grades, when stored in tanks that are entirely underground at gas stations. Similarly, the threshold is proposed to be raised to 100,000 gallons for the combined amount of diesel fuel stored in tanks that are entirely underground at gas stations. These thresholds are to be limited to retail gas stations, and are proposed by EPA to not apply to motor pools, marinas, propane fuels, and other types of locations.

- Raising the threshold for certain chemicals (list to be determined) to an "infinite threshold" level if the chemicals present a "minimal hazard and minimal risk" beyond the facility boundary to the community and the environment.

- The notice also provides clarification to some of the reporting requirements that previously caused confusion, including mixture reporting.

Toxic Release Inventory Reporting (Section 313): requires facilities that meet manufacture, process, or otherwise use activity thresholds for toxic chemicals to prepare an annual Form R report, which contains data on all ways that the chemical is: treated or recycled on-site; sent off-site; and released to the environment.

Expansions and revisions to guidance for EPCRA section 313 are many and varied, and include:

- Phase 2 industry expansion (62 FR 23834; 5/1/97) becomes effective 1/1/98, and not only extended EPCRA TRI reporting to seven commercial industrial service sectors, but also redefines the "otherwise use" threshold category. Otherwise use will be redefined for reports due July 1999 to include manufacture of a chemical in waste treatment activities, as well as treatment for destruction, disposal, or stabilization of a chemical if the waste management is performed on waste received from other locations. Therefore, any military installation that receives waste from other locations for disposal, treatment, or destruction must calculate the amounts of EPCRA section 313 toxic chemicals contained in the waste and include the chemicals in their calculation of the otherwise use threshold for the chemicals.

- In 1997, EPA inserted a little-known change to the reporting requirements for off-site transfers of metals and metal compound categories. Page 44 of the revised 1996 instruction document for Form R states that off-site transfers of metals and metal compounds should not be reported in section 8.7 "Quantity Treated Off-Site," but should instead be reported in section 8.1 "Quantity Released," which includes off-site transfers for disposal. This change extends to off-site transfers of metals and metal compounds to POTWs, which are reported in section 6.1, and should now be included in section 8.1, rather than 8.7.

- EPA "final guidance documents" for the newly added industries became available on EPA's Internet site in early October 1997, but EPA has revised the documents based on issues raised by the industries. Although these documents are designed for the new industries, they contain a number of issues that conflict with existing EPA, DoD, and U.S. Air Force guidance on EPCRA reporting.

- Effective November 3, 1997, EPA changed the address for courier delivery of TRI reports to: EPCRA Reporting Center, c/o Computer Based Systems, Inc., Suite 300, 4600 North Fairfax Drive, Arlington, VA 22203.

- EPA reissued the Section 313 Questions and Answers Document in November 1997 (EPA 745-B-97-008). The revised document includes the effects of the Pollution Prevention Act and other changes. Appendices to the document provide more comprehensive information on complex reporting issues.

- In February 1998, EPA prepared a Questions and Answers document aimed at the newly added industries, which contains some revised interpretations that will affect all reporting facilities. Some of the interpretations in the guidance conflict with existing EPA and DoD guidance. This Q&A document is currently only available on EPA's Internet site (http://www.epa.gov/opptintr/tri/).

- Phase 3 expansion: EPA still plans to require reporting for chemical use or materials management information based on an Executive Memorandum of August 8, 1995. EPA's position paper on reporting of chemical use or materials accounting information became available October 5, 1995, and despite strong opposition, and lack of clear information on how chemical use information can be applied, EPA remains committed that "full materials accounting information provides important insights." EPA published an Advance Notice of Proposed Rulemaking on October 1, 1996 (61 FR 51322), and plans to release a proposed rule in late 1998. Various data are being considered, including amounts of chemicals received at facilities, amounts contained in products, and amounts created or destroyed in processes, as well as amounts disposed of in wastes. When the proposed approach is finally developed, it will be essential for DoD installations to consider the possible impact on data collection and reporting under EPCRA and other environmental programs.

Recent Developments in Other Environmental Programs

The Clean Air Act Amendments (CAAA) were signed into law on 15 November 1990 (U.S.C. 7412). Late 1996, EPA established new regulations under section 112(r) of the Clean Air Act Amendments that will require military installations to perform detailed, process-specific evaluations for the amounts of certain chemicals involved in on-site activities (61 FR 31668; 40 CFR 68). The goal of the new requirements is to prevent accidental releases and minimize consequences of releases by focusing on highest risk chemicals and operations. Section 112(r) gives DoD installations the obligation to prevent accidents, operate safely, and manage hazardous chemicals in safe and responsible way. All stationary facilities are required to evaluate their operations for the presence of specific chemicals; develop Risk Management Plans that identify chemical hazards; work to reduce accidental chemical release potential and severity. CAA Section 112(r) covers a specific list of 139 Regulated Substances, which was initially developed based on the EHSs regulated under EPCRA. Each chemical has a threshold quantity, that when exceeded in a single "process" requires the facility to include the chemical in the Risk Management plan. The limits for Regulated Substances that are toxics range from 500 to 20,000 pounds, and the limit for each flammables is 10,000 pounds. Each Regulated Substance also has an established toxic or flammable endpoint, and the distance to that chemical's endpoint is a required part of the development of scenarios for the Risk Management Plan.

The level of detail involved in the plans will require that the information assembled be coordinated with current emergency planning, response, and management efforts to assure that consistent data are made available for use by on-site emergency planners, as well as regulatory agencies, and the public. EPCRA data that have been reported by military installations are currently be evaluated by regulatory agencies and as the basis for comparisons between waste reduction plans of facilities, and against commercial industry sectors. Risk Management Plan information can be expected to be applied to similar types of uses.

With the increased focus on public data access and risk in the prioritization of environmental issues, the Risk Management Plans can be expected to provide the basis for future environmental issues, requirements, regulatory controls, and enforcement activities that DoD operations will face.

Managing EPCRA Expansions

EPCRA is the one environmental regulatory program that EPA continues to expand. Increased focus is being placed on the release and spill reporting aspects of EPCRA through an Earth Day announcement from Vice President Gore, which included a call for industry to provide more health effect and risk information about the chemicals that they release.

DoD has already invested in EPCRA compliance. As EPA expands the chemical lists, tightens regulatory limits, and continues to make more data directly available on Internet, DoD installations must carefully accommodate the changes by revising tracking software,

expanding reporting procedures, and maintaining the records to show that the appropriate modifications have been made. EPCRA is an ever-evolving set of requirements; however, the most important challenge will be to carefully evaluate all EPCRA data reported for possible impact on other environmental programs, including the potential to establish benchmarks that may become default standards for the installation's next round of air and water permit negotiations.

A bill is under consideration in both houses of Congress, with the title of "Children's Health Protection and Right-To-Know More," which would expand EPCRA to cover all Federal facilities. Currently, DoD installations have the opportunity to establish EPCRA programs without the extreme monetary penalties faced by industry; penalties that can reach as high as $ 27,500 per day, per chemical, per year, per facility. Establishing and maintaining an EPCRA compliance program is essential, both to demonstrate DoD's ability to meet the requirements of the Executive Order (and that further legislative mandates are unnecessary), and to assure that compliance can be achieved if Federal facility coverage by EPCRA becomes a matter of law in the pending election year.

About the author:

June C. Bolstridge is President of the GAIA Corporation, and is certified as a Qualified Environmental Professional. She has more than 15 years experience assisting manufacturing and industrial corporations, and government agencies, including DoD, DoE, and EPA. Ms. Bolstridge provided support for EPA's implementation of EPCRA during its initial four years and assisted in the development of many of the EPA's instructional and guidance documents.

Ms. Bolstridge currently provides EPCRA technical assistance and training to federal and manufacturing facilities, and developed GAIA Corporation's *EPCRA Manual* and *EPCRA Handbook* to assist DoD facilities in meeting the EPCRA requirements. She is an adjunct professor at Johns Hopkins University, where she teaches a graduate-level Risk Management course in the Environmental Engineering and Science program.

Ms. Bolstridge holds a Masters in Environmental Engineering from the Univ. of Washington, and a B.S. Degree with Honors in Botany and Chemistry from SUNY College of Env. Science and Forestry, and Syracuse Univ.

Pollution Prevention in Hospitals

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Introduction

The cost of waste has become a big part of the cost of doing business. In many cases, the value of the material that becomes waste has not been included in the cost of waste. However, the value of the material is the largest component of the total cost of waste. Tracking the cost of waste as a component of the cost of doing business is in the best interests of all organizations. This is a study of waste at a rural hospital. Much of the waste from a medical facility is designed for single use and subsequent disposal. However, ensuring that what is purchased is received, and that the material purchased is used for the intended purpose offer the potential for significant savings.

Summary and Recommendations

The following table contains the recommendations resulting from an evaluation of a small rural hospital and an estimate of the expected effectiveness of each recommendation in reducing waste (both use of material and cost of disposal). Additional explanation is provided in the following pages.

Table 1 Recommendations

Recommendation	Potential Savings	Effort Required
Include waste issues in the in-service training required of every employee.	High	Medium
Evaluate the alternative technologies for disinfecting infectious wastes and talk with the suppliers of this equipment.	High	Medium
Re-evaluate the solid waste disposal contract to increase the utilization of the dumpster and optimize pickups.	High	Medium
Account for waste and the cost of waste as a function of departmental activities.	High	High
Establish commitments in supplier agreements to enlist their aid in reducing product use and waste. Track performance under these commitments.	High	High
Investigate energy saving options.	High	High
Spot check items received from suppliers.	Medium	Low
Develop a tracking system for waste generation with incentives for improvements.	Medium	Medium
Contact the Community Recycling Services with the idea of collecting cardboard to judge the potential for reducing the solid waste stream through recycling.	Medium	Medium
Consider reusable items with contracts for off-site cleaning.	Medium	High
The character of the waste from the pharmacy and the Chemo Containers should be investigated. All unused pharmaceuticals and empty containers should be returned to the suppliers.	Medium	High
Evaluate the placement and number of receptacles including recommendations from the users.	Low	Low

The Cost of Waste Disposal

The single biggest potential for reducing the cost of waste is to prevent material from becoming waste. In the health care industry, ways to reduce waste generation are limited. For this reason, disposal cost becomes a major component. Present disposal cost is outlined briefly here as a backdrop against which recommendations presented later can be evaluated.

Infectious waste disposal - The average rate for disposal of infectious waste for Fiscal Years 1995 and 1996 was $0.27 per pound.

Table 2 - Infectious Waste Disposal Rates

	Pounds	Cost	Rate $ per pound
***FY 1997**	40,212.00	$ 14,286.90	$ 0.36
FY 1996	108,016.68	$ 26,257.92	$ 0.24
FY 1995	104,678.27	$ 28,222.36	$ 0.27
Average	252,906.95	$ 68,767.18	$ 0.27

*** FY 1997 partial year**

The deviation in the partial FY 1997 data probably results from some FY 1996 waste charges being paid in FY 1997. If this is the case, the actual rate for FY 1995 and 1996 would be higher than illustrated here and the rate shown for FY 1997 would be lower. This information is based on the hospital safety committee reports on infectious waste. Since these data do not match the expenditure with the time the service was provided, the cost per ton varies from month to month.

Solid waste disposal - The components of the solid waste disposal charges include a monthly rental for the 30 cubic yard compacting dumpster of $300, a haul charge of $140 on a seven-day pickup cycle, and a disposal fee of $22.25 per ton.

General Waste Reduction Options

Check Purchased Material - It is important for users to check the material received from suppliers to insure that the purchased quantity is actually received. For example, if the contractor laundering linen charges based on his count of the items returned for use and overestimates, the hospital will be overcharged.

Even prepackaged items can be short. A spot-check on new items purchased to insure that when the package says 100 each it contains 100 items can be effective in spotting waste. Even slight deviations can add up to significant cost.

> Recommendation - Spot check items received from suppliers to insure the hospital is getting what it is paying for.

Employee Training - An employee with disposal options will place an item to be thrown away in the closest receptacle. This is true whether the item is recyclable and the closest receptacle is a trash container or the item is trash and the closest receptacle is designated for infectious waste. Without training, the employee will use the least effort required to dispose of waste and rationalize that as a savings to the organization. Training provides the motivation to change this behavior.

The key to encouraging employees to act responsibly in their disposal practices is three fold:

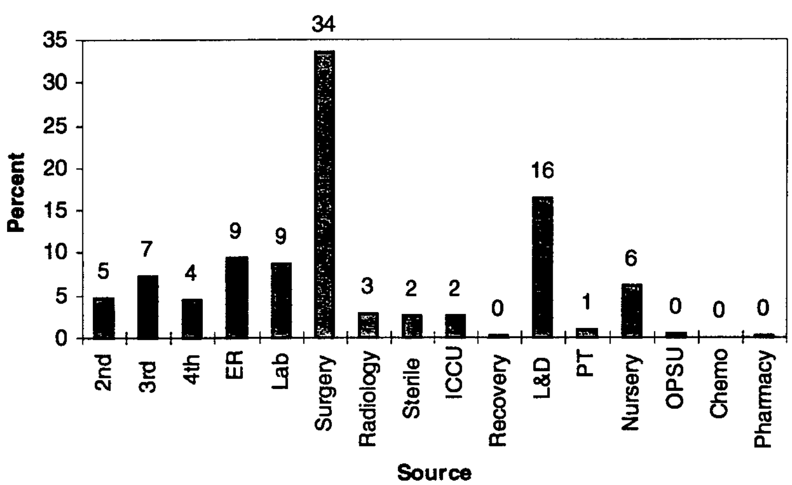
- Promote proper practices by making the receptacles conveniently available.
- Inform by training employees of the importance of proper disposal. It is as important to stress the need to keep non-infectious materials out of the infectious waste as it is to stress the importance of infection control and the proper segregation of infectious waste.
- Reward employees by providing incentives for improvements. This means measuring improvement and tracking problems limiting improvement.

> **Recommendation**: Include waste reduction issues in the in-service training required of every employee. Evaluate the placement and number of receptacles including recommendations from the users. Develop a tracking system with incentives for improvements.

Cost Allocation - The cost of waste includes the value of materials not used as intended in the care and treatment of patients, as well as, the cost of disposal. Departmental material cost are frequently applied back to the department needing the material. For example, it is clear that the cost of infant diapers should be charged against the budget for the nursery. Why then should the cost of disposing of dirty diapers be subsidized by the rest of the hospital?

Tracking and charging waste cost back to the appropriate department allows that department manager to focus on this issue like other budget items and increases the incentive for reducing that cost. The following figure illustrates available information on infectious waste generation by area.

Sources of Infectious Wastes



It is clear that Surgery and Labor and Delivery generate the bulk of the infectious waste and will probably be the best areas to focus a program to reduce the waste generated.

> **Recommendation** - Develop a method of accounting for waste and the cost of waste as a function of the departmental activities and use that information to allocate the cost of waste to the department generating it.

Packaging Reduction - Packaging waste can be reduced by ordering materials in reusable containers. An example would be anesthetic gases typically delivered in cylinders that are returned and refilled repeatedly. Applying this concept to other commodities can result in savings. For example, supplies (excluding sterile items) delivered in bulk rather than individually wrapped would reduce disposal of packaging waste. In fact, packaging for items that become infectious waste often end up in the infectious waste even though they are not infectious.

Work with Suppliers - Considerable waste reduction can be accomplished by working with suppliers to limit the amount of waste. The purchasing agents motto in years past has been that the more suppliers the better to keep prices down. In reality, this very practice can encourage waste and limit the hospitals ability to take control of its own waste generation. By developing a partnering relationship with suppliers, contracts can be used to encourage suppliers to show you how to use less of their product. For example, in return for an exclusive contract to supply syringes, a supplier could be asked to show the hospital how to use the mix of his product lines to reduce the amount of waste and cost of the material. The contract would set a goal based on cost and/or waste reduction that if not met would trigger reevaluation of the contract. Another benefit is that reducing the number of contracts will also reduce the time and effort needed to manage purchasing. Another example might be to evaluate reusable vs. disposable items. Off-site cleaning contracts like for laundering linen could provide the constant source of quality clean supplies at a lower cost.

Return to the Suppliers - A particularly useful technique to reduce waste at the hospital is to enter an agreement with suppliers to return any unused portions of materials purchased. This is particularly appropriate in the Pharmacy for expired or no longer needed pharmaceuticals. Damaged materials that cannot be used for patient care should also be returned. Items such as sponges and syringes, even if not contaminated, are still disposed of as medical waste since they may appear contaminated to the general public.

> **Recommendation** - Establish agreements with suppliers to enlist their aid in reducing material use and waste. Establish commitments in supplier agreements, and track performance under these commitments. Suppliers will have the most and best information on the use of their products. Consider reusable items with contracts for off-site cleaning.

Energy/Utilities Waste Reduction - The local power company has completed a comprehensive review of energy use at the hospital and presented several options for improving energy efficiency. The hospital is also working with Johnson Controls to develop specific alternatives for improving energy efficiency. Based on past experience, the potential for savings in the energy related areas can be high.

Significant savings are possible by effective energy management in hospitals. A hospital in Elkhart, Indiana saved over $100,000 per year on electrical energy with an initial investment of $85,000. Although the Elkhart hospital is a larger example, significant savings should be available through energy waste reduction.

Infectious Waste Cost Containment Options

As indicated under the Cost of Waste, infectious waste is the costliest waste for the hospital. The cost for disposal of this waste is also escalating faster than for other wastes. Training and allocation of costs to the generating departments have the greatest potential to generate savings. Other options that render medical waste safe for disposal in local landfills are discussed below.

Alternate Disposal Technology - The Electric Power Research Institute (EPRI) has published information on technologies to disinfect infectious waste and allow disposal in a sanitary landfill. Some of the technologies handle both sharps and other "red bag" wastes. Others are applicable to only one. This is particularly the case with technologies that handle only sharps. In order to properly evaluate the potential savings from these technologies, the portion of the waste represented by sharps must be known.

Sharps - A product known as a "needle-eater" is available for about $1,000. The product will render 75 to 150 syringes sterile and unrecognizable in a single container that can be disposed of with solid waste. Supplying 5 of these devices for use in the hospital would cost about $5,000. If sharps are only 10 percent of the medical waste poundage, the savings would be $2,500 to $3,000 per year. In addition, fewer red sharps boxes would be used.

Technologies vs. Types of Waste Treated

Technology	Blood/Fluids	Sharps	Chemo Waste	Cultures	Dialysis Waste	Hazardous Chemicals	Laboratory Waste	Pathology Waste	Soft Waste (gloves, linens, etc.)
Bio-Oxidizer	X	X	X	X	X	X	X	X	X
Demolizer	X	X	X	X	X		X		X
Pyroxidizer	X	X	X	X	X	X	X	X	X
TAPS Processor		X							
DSI 40 and DSI 2000		X							
dispoz-all 2000	X	X		X	X		X		X
MedAway-1	X	X		X	X		X		
Redloc System	X	X		X	X		X	X	X
Mark 1	X	X		X	X		X		X
EcoCycle 10	X	X		X	X		X		X
Isolyser Products	X	X				X			
Medzam	X	X	X		X	X	X		
Needle Eater		X							
Ster-O-Lizer	X	X		X	X		X		X

As an estimate of the sharps volume, a box of commonly used 3 cc syringes was determined to weigh about 2 pounds. The most commonly used red sharps box weighs about 2 pounds. An average of 48 such boxes is purchased per month. A red sharps box is estimated to hold over 2 boxes of used syringes. If 48 red sharps boxes are purchased per month, a like number on average will be sent to disposal. Based on this information, about 48 red sharps boxes are disposed of each month weighing about 7 pounds each accounting for a total of 336 pounds per month or 4,032 pounds per year. At a disposal cost of $0.28 per pound, the estimated cost for disposal would be about $1,130 per year. The volume of sharps would be higher since other types are placed in the same containers.

This evaluation does not include the cost of the disposal containers to receive the sharps, the disinfectant agent or the cost of solid waste disposal for the disinfected material.

Red Bag Waste - All of the alternatives that will handle portions of the infectious waste stream will also handle sharps. Some limit the volume of fluids or certain types of wastes. One device is the Dispoz-All 2000. The manufacturer recommends this unit for all infectious wastes except Chemotherapy and pathology wastes. In addition, the unit is not suited for disposal of hazardous chemicals. A unit that processes about 5 cubic feet in about 25 minutes costs about $59,500. If such a unit could process all of the infectious waste presently generated, the savings would pay for the unit in less than two years based on the cost of infectious waste disposal for fiscal years 1995 and 1996.

> **Recommendation** - Evaluate the alternative technologies for disinfecting infectious wastes and talk with the suppliers of this equipment. Adopting a plan to disinfect the waste at the hospital will help stabilize if not reduce disposal cost.

Contract Alternatives for Disposal - Any change in the handling of infectious waste will result in changes in the contract with the present disposal company. Significant reductions in the amount to be picked up can result in a dramatic increase in the cost per unit. The cost of backup medical waste disposal and the increase in solid waste disposal fees should be considered in any decision to make a change.

Solid Waste Cost Containment Options

Solid Waste Pickup Options - Based on the disposal cost as reported under "Cost of Waste", the cost of solid waste disposal is not as large as that for infectious waste. But because the waste is not infectious, options are available that do not apply to infectious waste. Based on the billing information provided, 3 - 4.5 tons per load are removed once per week in the 30 cubic yard compactor. A commonly used bulk density for uncompacted municipal waste (similar to hospital solid waste) is 150 pounds per cubic yard. A compactor should decrease volume by a factor of 3 to 5 on this type of waste. Therefore, the 30 cubic

yard container should hold up to 2.25 tons uncompacted or a maximum of 11.25 tons with a 5 to 1 compaction ratio. Based on these calculations, the 30 yard compacting roll-off is being used at less than half capacity. Contracting for a smaller container at a lower cost and/or converting to a dumpable container to reduce the $140 per trip haul fee could save a significant amount on a yearly basis.

Contracting with the present waste hauler for a smaller or dumpable container may not be possible because the local city offers that service exclusively within the city limits. Waste pickup service may be available at a lower cost from the city.

> **Recommendation** - Re-evaluate the solid waste disposal contract. The present 30 cubic yard roll-off is underutilized. Depending on the rates going to a smaller container that can be loaded to a truck at the hospital will reduce the cost even if a more frequent pickup schedule is needed. Consider contracting with the city for waste pickup.

Recycling - The hospital does not have an official recycling program in place. Typically, the revenue generated by recycling programs does not cover the cost. However, when reduced, disposal cost and public relations benefits are included, a net cost reduction may be possible.

The University of Tennessee estimates that a 100 bed hospital will generate about 4 tons of cardboard, 1.5 tons of paper, and 2 tons of plastic per month. During March and April 1997, eight solid waste pickups yielded a total of 29.7 tons. If 13 tons were paper and cardboard, they represent 44 percent of the total solid waste. EPA estimates that paper and cardboard is about 40 percent of municipal waste. For each ton removed from the waste stream by recycling, the disposal cost of $22.25 will be saved. Further, with each reduction in total waste, the need for a device as large as the presently underutilized 30 cubic yard roll-off is reduced.

The community has a relatively new recycling program called the Community Recycling Services. The program is based on a site near the hospital. The project is still developing but recyclables are being collected and containers to collect recyclable materials may soon be available.

Certainly, recycling should not take the place of source reduction. However, recycling things like cardboard and paper can be easily implemented and the result can be a savings in tonnage, in the number of pulls per month, and in the type equipment needed.

> **Recommendation** - Contact Community Recycling Services with the idea of collecting cardboard initially. Some training and a few weeks experience should demonstrate the viability of recycling. If successful, recycling can be expanded to include white and/or mixed paper and other recyclables.

Hazardous Waste

According to the Safety Committees record, the only hazardous waste generated is the pharmacy. This amounted to 288 pounds in Fiscal Year 1996. This material was disposed of with the infectious waste. The character of the waste from the pharmacy should be investigated. Unused pharmaceuticals should be returned to the suppliers. Alternative disposal methods for the chemo containers should be investigated. The laboratory may also be an unrecognized source of hazardous waste. The disposition of hazardous chemicals from the laboratory should be investigated.

Session V
Compliance Through P^2 Initiatives

Session Chairpersons:

Mr. Milt Rindahl, HQ AFMC/CEVV
Dr. Joe Milligan, Labat Anderson

Lessons Learned: Compliance Through P^2

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Why compliance through P2 now?

We've been doing both - and quite successfully according to the data we use to measure our progress. Measuring the data? That's one key right there - the data we measure our progress with! Is it the right data? Is the data correct? For P^2 progress, we measure EPA-17 or AFMC-24, ODS, hazardous waste, and others. These measurements are based on very specific waste streams and we have made a lot of progress in these areas. But there are two main problems with these measurements:

- *They are not related in any way to processes or activity levels. When our activities change, the changes but we don't see the trends.*
- *They lead to P^2 programs based on hindsight because they focus on waste generation.*
- *They are no longer related to today's compliance issues.*

Old P^2 programs lead to reductions in the waste measured but, as activities changed and new compliance issues unfolded, dollars spent for compliance continued to rise. Focusing on waste quantities not related in any way to activity levels does help us with today's compliance issues, such as current quantitative permit conditions, but it doesn't help with qualitative conditions nor with forecasting future compliance issues. By shifting the focus to compliance issues first, we focus on qualifiable regulatory issues before deciding what our P^2 priorities are. Then we can choose the data we need to track our progress.

Today's business climate necessitates a change in how we approach environmental problems. Billions of dollars are spent each year to cleanup past improper disposal practices and old problems. The lesson learned is that pollution costs us more than money. Pollution costs us - for treatment, for transportation and disposal, and potentially for cleanup. And yet, billions of pounds of toxic materials continue to be released annually into streams, air and onto land as evidenced by the annual SARA TRI reports. These billions of pounds represent expensive raw materials, lost productivity, and inefficient processes. The loss of these materials to the environment also represents long term liabilities and intangible costs. Pollution prevention programs began as extensions of waste minimization programs that are specifically directed at reducing the generation and disposal of hazardous waste. Today, effective P^2 strategies focus on elimination rather than reduction; P^2 combines regulatory compliance with continuous improvement, materials management, and total cost accounting.

Why P^2 to solve the problem? Because we see a fundamental change at EPA - an aggressive thrust toward multi-media programs that will prevent waste as a first approach and achieve compliance in a simple yet cost-effective way. P^2 was once a voluntary exercise - now it is a business necessity. And a strong program will enable you to:

- Eliminate the need for compliance

Or, failing that,

- Lower equipment and raw material costs
- Lower treatment and disposal costs
- Lower compliance costs
- Improve management and operating costs
- Improve productivity
- Minimize liabilities and cleanup costs
- And earn the trust of your regulators and community

Where do we start?

The compliance issues need to be considered first. Figure 1 illustrates a partial compliance matrix for a small Air Force Base. Present and future compliance issues are listed horizontally; waste streams by process area are listed vertically. Ranking the importance of each issue is often site-specific. One set of ranking criteria could be as follows:

1. Compliance importance (regulatory or otherwise)
2. Potential cost of solution
3. Simplicity of solution
4. Potential implementation success

Qualitative numbers would have to be generated for these criteria to allow the rankings. Using these, we can prioritize processes and their waste against compliance issues. Once prioritized, the P^2 process can begin.

Opportunity assessments, options development, and feasibility analysis follow.

Case Studies

Where do we end up? Today's environmental climate necessitates the use of different tools to develop and analyze our options. Past P^2 opportunities were analyzed on the basis of technical feasibility, waste elimination or reduction, and cost. This presentation will look at three cases where our decisions might have been different if our tools had been modified to account for compliance upfront and to consider our data needs differently.

Figure 1

REGULATORY COMPLIANCE MATRIX

RUST PROJECT NO. ....

COMPLIANCE ITEM		REGULATORY									
		AIR							WASTE		
		STATE		FEDERAL		ATTAIN/ NONATTAIN	ENFORCEMENT ACTIONS	NPDES	RCRA		SOLID WASTE
WASTESTREAM	SUM OF PRIORITY RANKINGS	CONSTRUCTION PERMIT CONDITIONS	OTHER	TITLE III	TITLE V				HAZARDOUS WASTE	PCBs	
CONTRACTOR OPERATED PARTS STORE	0										
	0										
ENTOMOLOGY SHOP											
Pesticides	3								3		
FIREFIGHTING											
Halon	2		2								
MEDICAL	3										3
Biohazards	0										
Hazardous Waste	0										
Radiology	0										
MISCELLANEOUS											
Lab Packs	4								2		2
PAINT SHOP											
Air Emissions	1				1						
Crushed Paint Cans	2										2
etc	0										
	1								1		
	1								1		
PHARMACY											
Hazardous Waste	0										
Materials shelf life	1								1		
	0										
Etc.											
	1				1						
	4								2		2
	0										
	1								1		
	3.5								1.5		2
	4								2		2
TRANSPORTATION AREA & WHEEL/TIRE SHOP											
	2								1		1
	4.5								2		2.5
	2.5								1.5		1
	2										2
	2										2
UTILITY OPERATIONS											
	1				1						
	0										
	0										
	0										
	0										
	2										2
	1.5										1.5
	3										3
	3										3
	3						3				
	6						3				3
	6						3	3			
WEAPONS SYSTEMS/MAINTENANCE SHOP											

Figure 1

REGULATORY COMPLIANCE MATRIX

RUST PROJECT NO. ....

COMPLIANCE ITEM		REGULATORY									
		AIR							WASTE		
		STATE		FEDERAL		ATTAIN/ NONATTAIN	ENFORCEMENT ACTIONS	NPDES	RCRA		SOLID WASTE
WASTESTREAM	SUM OF PRIORITY RANKINGS	CONSTRUCTION PERMIT CONDITIONS	OTHER	TITLE III	TITLE V				HAZARDOUS WASTE	PCBs	
	1				1						
	2										2
	2		2								
	2								1		1
	2								1		1
	6								3		3
	3				3						
	2										2
	2		2								
	1								1		
	1								1		
	2								1		1
	2								1		1
	2								1		1
	1								1		
	1								1		
	1				1						
	2										2
	0										
	1								1		
	1								1		

Designate Priority As

Compliance Through Pollution Prevention: Strategy and Implementation at Edwards AFB

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1.0 INTRODUCTION

Edwards Air Force Base (AFB), located in the Mojave desert of southern California approximately 100 miles northeast of Los Angeles, is required to comply with the requirements of the California Environmental Protection Agency (CA-EPA) and the US Environmental Protection Agency (US-EPA) for air pollutant emissions, hazardous waste disposal, and toxic release inventory reporting (TRI). Specific CA-EPA agencies that Edwards AFB must deal with on a regular basis include California Air Resources Board (CARB) and Department of Toxic Substance Control (DTSC). In addition, Department of Defense (DoD), United States Air Force (USAF) and Air Force Materiel Command (AFMC) instructions and directives impose additional requirements for air pollutant emission source management, hazardous waste management and pollution prevention (P2).

Traditional environmental compliance includes paying fees, enacting procedures and processes to meet rules and regulations, and inspecting sites for compliance. In 1997, the Edwards AFB environmental compliance program addressed over 3,100 identified compliance sites (air emission sources, hazardous waste storage sites, installation restoration cleanup sites, under and above ground storage tanks, and water resources). The programmatic resources and costs required to address the resulting multiple compliance requirements are considerable. Even at a high level of programmatic integration, the current situation is at best a reactive approach to environmental management.

When practiced in a traditional manner, P2 includes source reduction and elimination, recycling and reuse, and treatment. Since 1994, the Edwards AFB P2 program was focused on achieving reductions in DoD, USAF and AFMC thrust areas (ozone depleting substances, US-EPA 17 chemicals, TRI chemicals and solid waste). While the short term resources and costs required for these P2 projects were often considerable, long term resource and cost reductions have been realized. However, within the DoD, USAF and AFMC guidances established for P2, compliance considerations were often not a motivating factor (although compliance was often recognized as a result). Although the methodologies for a P2 initiative driven by compliance considerations are essentially the same as the practices already in place, a formalized program is necessary to guarantee results.

A proactive P2 program seeks to reduce, and eventually eliminate compliance requirements and costs, while at the same time reducing pollution released to the environment. This concept can be best described as Compliance Through Pollution Prevention (CTP2). In DoD's current budgetary climate, CTP2 has the highest potential for achieving true long term environmental resource and cost reductions, an important consideration. The remainder of this paper demonstrates how a proactive CTP2 program driven by air quality compliance requirements at Edwards AFB has been developed.

2.0 CTP2 STRATEGY DEVELOPMENT

At Edwards AFB, the Environmental Management P2 Branch (EMCP) developed a strategy that addresses CTP2 within the context of the base's USAF mission and operations, and federal, state and local compliance requirements. Such a strategy, namely augmenting DoD, USAF and AFMC P2 objectives with ones that are derived from specific compliance requirements imposed on Edwards AFB, is a necessary first step to ensure that appropriate targets for CTP2 efforts are defined, and that subsequent P2 opportunity assessments are focused on those targets.

Edwards AFB is home to the Air Force Flight Test Center (AFFTC). The primary mission of AFFTC is the test and evaluation of USAF aircraft weapon systems. In the course of accomplishing its test missions, the center uses a wide

range of hazardous materials and processes, resulting in the generation of hazardous waste, air emissions and pollution. In 1997, over 2,700 identified air emission sources had some level of compliance requirements. These include:

- Permitted sources regulated by local air districts[1],
- Emission sources tracked for local reporting requirements[2],
- Emission sources tracked for California Air Toxics "Hot Spots" information and assessment[3], and
- National Emission Standard for Hazardous Air Pollutants (NESHAP) for aerospace manufacturing and rework (administered through the local air districts)[4].

The air quality compliance requirements for Edwards AFB are further complicated by the fact that the bulk of base is in a serious ozone non-attainment area (Kern County). It is important to recognize, however, that not only is such a circumstantial factor important in establishing rigorous compliance requirements, it is also a fundamental driver in setting CTP2 objectives that are appropriate for Edwards AFB.

To be effective, the CTP2 strategy for Edwards AFB must be proactive and anticipate and address future air compliance issues. Future air quality compliance requirements that will affect Edwards AFB include:

- US-EPA Clean Air Act (CAA) Title V permit (to be issued in late 1998)[5],
- CAA Risk Management Planning[6], and
- Future NESHAP requirements for jet engine and rocket motor testing.[7]

The basic CTP2 strategy for air quality compliance was developed to address three principle areas. These areas were selected based on having the greatest potential to reduce compliance resource and cost requirements in the present and future air quality compliance programs, and reduce environmental pollution. Activities designed to reduce compliance vulnerability were also identified.

2.1 Permit and NESHAP Compliance

In 1997, 446 emission sources were affected by permit and NESHAP compliance requirements. The strategy to reduce both current, and future, permit and NESHAP requirements includes; (1) eliminate requirement by reducing emissions, or other applicable factors, below compliance threshold; (2) reduce compliance operating conditions by reducing or eliminating specific pollutant emissions, or other applicable factors; and (3) reduce compliance administrative requirements by reducing emissions, or other applicable factors to well below their respective permitted limitations. Specific permitted and NESHAP compliance sources to be addressed by CTP2 are listed in table 1.

2.2 California Air Toxics Information and Assessment

In 1995, Edwards AFB provided an Air Toxics Information and Assessment update report to the local air districts for the reporting year 1994. At that time, and in conjunction with the program requirements, Edwards AFB was classified as an "Intermediate Level" facility due to having a prioritization score between 1 and 10.

In 1999, Edwards AFB will be required to submit an update report for reporting year 1998, followed by prioritization re-evaluation. If Edwards AFB can achieve a prioritization score of <1, then Edwards AFB would be reclassified as a "Low Level" facility and become exempt from further Air Toxics compliance and regulatory requirements. A secondary objective is to at least limit emissions of targeted Edwards AFB specific Air Toxics listed chemicals such that the 1998 prioritization score is maintained are at the current level. The methodology to achieve a prioritization score of <1, or the secondary objective, is to reduce emissions of targeted Edwards AFB specific Air Toxics listed chemicals to levels that will achieve the objectives. Specific Air Toxics chemicals to be addressed by CTP2 are listed in table 2.

2.3 Risk Management Planning

In 1999, Edwards AFB will be required to submit a risk management plan (RMP). Per the RMP requirement, Edwards AFB will fall into one of three possible "programs", each with differing levels of compliance requirements. Program 1 has the least requirements, while program 3 has the most extensive requirements. For Edwards AFB, the goal is to fall within the program 1 RMP requirement. The strategy to achieve the program 1 goal is to reduce the use or storage of targeted Edwards AFB specific RMP listed chemicals below their respective trigger thresholds. Specific RMP chemicals to be addressed by CTP2 are listed in table 3.

Table 1. Specific permitted and NESHAP compliance sources to be addressed by CTP2.

Source Category	Compliance Category	Process Description	Emissions
External Combustion	Local Air District Permits	Natural Gas Boilers	NOx
Internal Combustion	Local Air District Permits	Aircraft Ground Support Equipment (AGE)	NOx
Painting	Aerospace Rework NESHAP	Aircraft Paint Booths	HAPs
Jet Engine Test Cells	Jet Engine Testing NESHAP	Jet Engine Testing	NOx and HAPs

Table 2. Specific Air Toxics chemicals to be addressed by CTP2.

Chemical Name	Air Toxics Risk Category[1]	Primary Emission and Process Sources
Acrolein	Acute Non-Cancer	Jet Engine Testing
Chlorine	Acute Non-Cancer	Water Treatment
Chromium Compounds (Hexavalent)	Chronic Non-Cancer and Cancer	Aircraft Painting, Adhesive/Sealants, Soldering/Welding
Ethylene Glycol and Glycol Ethers	Acute Non-Cancer	Coolants
Isocyanate Compounds	Acute and Chronic Non-Cancer	Aircraft Painting, Adhesives/Sealants
Lead Compounds	Acute Non-Cancer	Jet Engine Testing, Soldering/Welding, Adhesives/Sealants
Nickel Compounds	Acute Non-Cancer	Soldering/Welding

[1] Air Toxics Risk Category refers to the 1994 risk prioritization results that had the greatest impact on the prioritization score.

Table 3. Specific RMP chemicals to be addressed by CTP2.

Chemical Name	Primary Process Sources
Chlorine	Water Treatment
Hydrogen Chloride	Rocket Motor Testing

3.0 CTP2 PROJECTS and PROGRESS

With a CTP2 strategy in hand and a list of targeted sources, the next step was to develop and apply specific CTP2 projects to address these sources.

3.1 PERMIT AND NESHAP COMPLIANCE

Sources addressed under the permit and NESHAP category represent sources that have the greatest potential for permit fee reduction or NESHAP compliance requirement reduction or elimination. A summary of the CTP2 projects and status for each source is given in table 4.

External Combustion: Natural gas fired boilers account for a significant fraction of permit fees and compliance costs (required periodic source testing). Boilers can be de-rated by adjusting the burners to reduce the boiler heat output to below permit threshold limits. The results are reduced emissions of nitrogen oxides (NOx), and elimination of permit compliance requirements (for boilers de-rated below 5 million BTU/hr) and source testing requirements (for boilers de-rated to between 5 and 10 million BTU/hr). Given the ozone non-attainment status of Kern County, sources of ozone precursors (such as NOx) can be expected to receive a high priority from local regulators. Thus efforts to reduce NOx emissions are aligned with regulatory agency priorities. In 1997, 23 boilers were identified[8] as potential candidates for de-rating, with an estimated $43,000/year cost savings. This project is currently under evaluation.

Internal Combustion: Internal combustion (IC) engines in aircraft ground support equipment (AGE) accounted for 38% of the total 1996 NOx emissions from Edwards AFB[9]. The major concern is the impact this source has on local ozone levels (NOx is an ozone precursor). Technologies for reducing NOx emissions from IC engines by 30-70% have been identified[10]. These IC engine technologies include water-in-fuel firing, selective catalytic reduction and NOx filtration. All of these technologies are currently under testing by the Air Force Research Laboratory (AFRL)

Table 4. CTP2 projects and status for permitted and NESHAP compliance sources.

Source Category	CTP2 Project	Project Status
External Combustion	De-rate boilers below 5 million BTU/hr, or between 5 and 10 million BTU/hr	Project under evaluation
Internal Combustion	Install IC Engine modifications (water-in-fuel firing, selective catalytic reduction) and NOx filters	On-going effort by Air Force Research Laboratory program - testing in progress
Painting	Weapon systems and base-wide P2 opportunity assessments to reduce hazardous material usage.	On-going effort for FY 1998
Jet Engine Test Cells	Research NOx (and potential HAP) control systems	FY00 SBIR Phase I

as part of a USAF wide technology needs study. Edwards AFB will continue to monitor these tests to identify those technologies that can be successfully implemented in the future.

Jet Engine Testing: Jet engine testing accounted for 47% of the total 1996 NOx emissions from Edwards AFB[9]. Jet engine testing also accounted for 21% of hazardous air pollutant (HAP) emissions in 1996. The major concern is the impact this source is having on local ozone levels. In addition, a NESHAP is expected for jet engine testing (due November 2000) and addressing possible source reduction options now could have long-term benefits for avoiding possible testing restrictions due to the new NESHAP. Technologies for reducing NOx emissions from jet engine testing have been identified[11,12], and may also have possible applications for HAP reduction (including Air Toxics chemicals). Edwards AFB plans to evaluate NOx and HAP control technologies for applicability to the base's test cells through a Small Business Innovation Research (SBIR) project.

3.2 CALIFORNIA AIR TOXICS INFORMATION AND ASSESSMENT

Sources addressed under the Air Toxics chemicals category represent sources that have the greatest potential to reduce the 1998 update prioritization evaluation score to <1. A summary of the CTP2 projects and status for each chemical is given in table 5.

Chromium Compounds (Hexavalent): Of the Air Toxics chemicals listed in tables 2 and 5, by far the most important to the CTP2 strategy for Air Toxics are hexavalent chromium compounds. Most of the sources that emit hexavalent chromium compounds are uncontrolled fugitive sources. Such sources lend themselves well to classic P2 opportunity assessments (PPOA). In a typical PPOA, chemical usage is evaluated and changes made to processes, procedures and materials to reduce or eliminate the chemical. Edwards AFB already has two PPOA projects that are on-going; a base-wide facilities opportunity assessment; and a weapon system specific opportunity assessment. Since most of hazardous materials used at Edwards AFB are for weapon system maintenance, a weapon system specific P2 opportunity assessment has the greatest potential for achieving the CTP2 goal for Air Toxics chemical reduction. Specific opportunity assessment recommendations are currently under development, with expected implementation to occur in FYs 1998 and 1999.

Ethylene Glycol and Glycol Ethers: One of the Air Toxics chemicals that is being addressed by a specific project is ethylene glycol and glycol ethers. The primary source of emissions for this chemical is from engine coolant losses during coolant change-outs. To minimize these losses, Edwards AFB is purchasing specialized recycling units that will recover the engine coolant, and filter the coolant for reuse. This project is in the equipment purchase phase and is expected to start up in mid 1998. An additional benefit of recycling ethylene glycol and glycol ethers is reduced generation of hazardous waste, and the resulting disposal costs and very significant compliance requirements. Indeed, this project is a prime example of how CTP2 can achieve impacts on different compliance program requirements.

All Other Air Toxics Chemicals: The same PPOA methodologies already discussed apply equally as well to the other Air Toxics chemicals. Specific PPOA recommendations are currently under development, with expected implementation to occur in 1998 and 1999. It is important to note that many of the CTP2 projects at Edwards AFB address multiple compliance issues. The PPOA projects discussed are the primary method for achieving NESHAP compliance for painting emission sources under permit compliance. The jet engine testing NOx reduction project also has the potential to reduce several Air Toxics chemicals.

Table 5. CTP2 projects and status for Air Toxics chemicals.

Chemical Name	CTP2 Project	Project Status
Acrolein	Research NOx (and potential HAP) control systems	FY00 SBIR Phase I
Chlorine	None	
Chromium Compounds (Hexavalent)	Weapon systems and base-wide P2 opportunity assessments to reduce hazardous material usage.	On-going effort for FY 1998
Ethylene Glycol and Glycol Ethers	Install coolant recycling systems for base-wide use	Equipment purchases in progress
Isocyanate Compounds	Weapon systems and base-wide P2 opportunity assessments to reduce hazardous material usage.	On-going effort for FY 1998
Lead Compounds	Weapon systems and base-wide P2 opportunity assessments to reduce hazardous material usage.	On-going effort for FY 1998
Nickel Compounds	Weapon systems and base-wide P2 opportunity assessments to reduce hazardous material usage.	On-going effort for FY 1998

3.3 RISK MANAGEMENT PLANNING

Sources addressed under the RMP chemicals category represent sources which have the greatest potential to achieve a level 1 RMP if their use or storage can be reduced to levels below RMP thresholds. A summary of the CTP2 projects and status for each chemical is given in table 6.

Chlorine: Based on 1997 use or storage, chlorine is the one RMP listed chemical that singularly puts Edwards AFB into at least a program 2 RMP. The biggest issue is storage in pressurized cylinders in excess of 2,500 pounds (the RMP trigger), and all in one location. Since the main application is for water treatment, a CTP2 project has been initiated to evaluate and implement better management practices to reduce storage below the RMP trigger.

Hydrochloric Acid: At Edwards AFB, hydrochloric acid occurs mainly as an unavoidable combustion product from rocket motor testing. It is of concern from a RMP perspective because rocket motor testing can generate and release large quantities very quickly (similar to an accidental release from a storage tank). Currently, possible options for controlling hydrochloric acid emissions from rocket motor testing are being investigated.

4.0 CONCLUSIONS

At Edwards AFB, a review of the base's air quality compliance requirements has led to the development of a CTP2 strategy that seeks to reduce and eliminate air quality compliance requirements and costs. This CTP2 strategy has led to several P2 projects (new and on-going) that are designed to achieve the CTP2 goals, and reduce pollution into the environment. Since most of these projects are in various phases (development, funding, on going and implementation) and not yet complete, the ultimate outcomes are still not known.

As promising as CTP2 appears to be, there are potential roadblocks. Most prominent of these roadblocks is the need to change "mind-set". Traditional environmental compliance amounts to little more than paying the "bill". This is often the most convenient way, and is the typical result of short term thinking. CTP2 requires that environmental professionals make a long-term evaluation of an environmental problem, and develop long term solutions to address it. Likewise, CTP2 will require negotiation with regulators to replace existing compliance conditions with a commitment to pursue P2, resulting in overall reductions in compliance requirements and fees. Almost as difficult as the "mind set" problem is the need for change in the way organizations plan funding. Often long term funding to reduce and eliminate environmental compliance is over ruled by the need to show short term return on investment, and demonstrate current compliance.

Irrespective of actual the actual monetary benefits realized, it is clear that CTP2 is a viable tool to achieving, maintaining and reducing compliance requirements. A successful CTP2 program requires formally developed

Table 6. CTP2 projects and status for RMP chemicals.

Chemical Name	CTP2 Project	Project Status
Chlorine	Implement better management practices for storage	Under discussion with base supply
Hydrogen Chloride	FY 2000 project under development	

strategies and objectives, and must be part of an overall P2 program. Faced with ever shrinking budgets, CTP2 has the highest potential for achieving true long term environmental resource and cost reductions, while at the same time achieving improvements to the quality of the environment. This is the essence of effective Environmental Leadership.

5.0 ACKNOWLEDGMENTS

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Pollution Prevention as a Means to Environmental Compliance

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The Air Force, and in particular the Air Force Materiel Command (AFMC), has invested heavily in pollution prevention (P2) for the past several years. The objective of these investments was primarily to reduce the use of hazardous materials in accordance with Air Force goals. There was no regulatory requirement. During the same period, a concerted effort in the environmental compliance arena drastically reduced the number of permit noncompliances to a relatively low, static number. Many of these are difficult to resolve using conventional approaches. AFMC is now challenged with achieving complete environmental compliance in spite of rapidly declining budgets. AFMC recognizes that a new way of doing business is needed in order to achieve their objective: the overall reduction in costs and risks associated with environmental permits. The new business paradigm is *Compliance Through Pollution Prevention (CTP^2).*

Background

Both Secretary of the Air Force Widnall and former Chief-of-Staff General Fogleman have identified that the Air Force needs to rethink the methodology by which Air Force ESOH programs are managed. General Fogleman has stated: "Our future commitment to...ESOH programs will not be diminished. We must transcend traditional boundaries so we can ... support the Air Force's vitality in the 21st century."

On 3 August 1993, President Clinton signed Executive Order (E.O.) 12856: Federal Compliance with Right-to-Know and Pollution Prevention Requirements. The order ambitiously states that the federal government should establish itself as a leader in the P2 arena. The President encouraged all federal agencies to turn to P2 as the primary

means to achieve compliance with environmental laws and regulations, reduce environmental costs, and decrease future liability. His rationale is an obvious one; if you don't engage in regulated environmental activities then you can't be out of compliance.

His Order requires the development of strategies in four areas:

- Toxic Chemical Reduction Goals,
- Acquisition and Procurement Goals,
- Toxics Release Inventory / Pollution Prevention Act Reporting, and
- Emergency Planning and Community Right-to-Know Reporting Responsibilities.

The Environmental Protection Agency (EPA) subsequently convened a working group to develop a plan for implementing the E.O. The product, finalized on 3 September 1996, established the Code of Environmental Management Principles (CEMP) for federal agencies. The five identified principles are:

- Management Commitment,
- *Compliance Assurance and Pollution Prevention*,
- Enabling Systems,
- Performance and Accountability, and
- Measurement and Improvement.

DoD subsequently endorsed the CEMP at the Deputy Under Secretary Level. Within DoD, progress towards implementing the CEMP is varied. The Marine Corps (USMC) has implemented their Pollution Prevention Approach to Compliance Efforts (PACE) program. The PACE goal is to increase investments in P2 solutions to compliance issues to 30% of the USMC environmental management budget by FY 00.

The Air Force already has several elements of an extensive environmental management system (EMS) in place. Tone and direction are set through Air Force Directives and Instructions that are augmented by targeted programs such as the Environmental Compliance Assessment and Management Program (ECAMP) to assess compliance and Pollution Prevention Opportunity Assessments (OAs) to identify P2 opportunities. Each effort was developed and has evolved to address a particular need but they are not totally linked. As funding lines draw down, the need to operate more efficiently increases and CEMP presents an excellent opportunity to accomplish this by implementing a CTP^2 paradigm in a systematic manner.

CTP^2 is an environmental management strategy founded on the principle that P2 is the best means to achieve environmental compliance, reduce environmental costs, decrease liability, and meet DoD / Air Force environmental requirements. The ultimate vision for CTP^2 is to reduce environmental risk and eliminate environmental permits where it is cost-effective.

The Air Force has invested substantial resources in P2 with difficult to quantify results. In prior years, P2 investments were made mostly for the sake of reducing waste

generation and the associated pollution risk with little concern for other drivers such as environmental compliance. The new business paradigm established by General Babbitt mandates that sound business practices underlie all future investments, including those in P2. Accordingly, AFMC has decided to target future P2 investments at those having the potential for rapid payback through reduced compliance costs.

The Air Force recognizes that several impediments exist to implementing *CTP²*. Currently, the P2 and compliance programs exist in their own "stove-pipes" and have separate funding. P2 projects must compete for funding with end-of-pipe compliance projects. As the latter are typically "must fund" projects, P2 projects are much more difficult to justify.

AFMC has already begun to establish P2 as the best means to achieve compliance in the belief that properly targeted P2 efforts should result in less compliance requirements. Compliance funding requests are being evaluated to determine if a long-term P2 fix might be available. AFMC is increasing efforts in the DoD/EPA ENVVEST program. At some AFMC bases, stronger links are being forged between the compliance and P2 organizations through integrated product teams. AFMC bases have been asked to appoint *CTP²* project officers.

The Air Force's position and need for an integrated environmental management strategy is not unique. Many private companies have been faced with the same challenge. Some have yet to address the issue. Others, such as Intel Corp., have attacked the problem head-on setting and achieving zero emission goals for new manufacturing facilities. Expertise in achieving compliance through pollution prevention exists for AFMC to draw upon.

Opportunity

The Air Force now has an opportunity, grown out of necessity, to develop a new approach to use tools such as P2 opportunity assessments to achieve compliance and ultimately significantly reduce compliance burden. It is anticipated that to a great extent, this can be accomplished by linking existing Air Force environmental programs and resources through an integrated framework. When fully functional, this unique approach will define the path to reduced compliance burden within the Air Force.

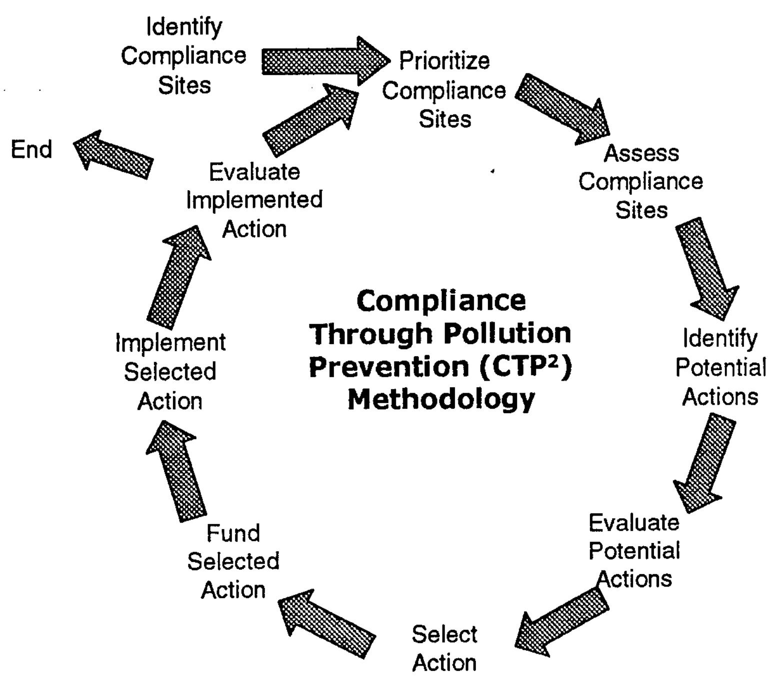
Approach

AFMC has embarked upon an aggressive multi-phased program to develop the new *CTP²* approach. The first phase consists of three activities. The first activity is to determine to what extent AFMC has programs in place and functioning that conform to the 5 CEMP principles. In the course of this gap analysis, AFMC will be looking for opportunities to ingrain a *CTP²* philosophy into the way they do business.

Concurrent with the Gap Analysis, AFMC will identify pollution prevention best management practices not currently in use by AFMC that could be migrated to the

Command to support CTP^2. The focus will be on actual management practices rather than field level activities such as replacing one solvent for another. AFMC is most interested in those environmental management systems that could be used to reduce compliance burden and/or costs.

The Gap Analysis and the P2 best management practices will be merged to form an action plan detailing the most direct path that AFMC should take to achieve environmental permit elimination. Until the Action Plan is complete, it is not possible to fully define the next steps. However, for planning purposes we have conceptualized the CTP^2 methodology presented in the following figure.



The CTP^2 methodology is fashioned after a similar methodology developed for the EPA by their Science Advisory Board and consists of 9 steps.

1. Identify Compliance Sites: AFMC has developed a basis for defining compliance sites to the lowest possible unit for each permit. As a result, they have defined approximately 18,000 compliance sites in the Command. These sites establish the starting point for the methodology.

2. Prioritize Compliance Sites: It simply isn't possible to address 18,000 Sites at one time. **Criteria must be established** and a procedure developed to determine which Sites should be addressed first. Each Site has its own characteristics in terms of ecologic and human health risk, mission criticality, likelihood of noncompliances, etc. that need to be established and evaluated to determine which Compliance Sites should be addressed first.

3. Assess Compliance Sites: Then each Site must be examined to first determine if it is properly characterized and then what unique characteristics it possesses making it a candidate for various pollution prevention actions.

4. Identify Potential Actions: The Site characteristics define a suite of pollution prevention actions that may be applicable for that site. The criteria and process to accomplish this flow directly from the Step 3 and become a mechanical process. The potential actions may be technological as well as policy.

5. Evaluate Potential Actions: The suite of identified potential actions is then culled to eliminate those that are clearly unacceptable for this particular situation. Also, corrective actions may be identified that are a combination of two or more of the identified potential actions. The process results in a short list of potential actions for consideration by the decisionmaker.

6. Select Action: The decisionmaker(s) selects the action to be funded. The selection process can be simply based upon values or founded on one of the more sophisticated decision science processes.

7. Fund Selected Action: Once the "best" option has been selected, the funding source can be selected.

8. Implement Selected Action: The "best" option has been selected and funds have been appropriated. It is now time to implement the action.

9. Evaluate Implemented Action: Once the action has been implemented, it will be evaluated to determine to what extent it is effective. If the permit requirements for the compliance site have been satisfied and the permit can be withdrawn, then <u>that</u> compliance site can be eliminated from the process where it makes sense to do so. If it can't be eliminated, then the site is returned to the pool of compliance sites for future prioritization.

As envisioned, the process will be very reproducible and lend itself to field implementation. Because it must feed into higher level decision strategies it will be built around an interactive computer support system to assure that the information available to the decision maker is as current as possible.

Currently, it is planned that the *CTP²* Methodology will be fully developed and ready for field testing by the end of FY 98. Subsequent, field tests will proof the concept to assure that it is fully implementable.

Pollution Prevention Implications of Emissions Trading Programs at Federal Facilities (#223)

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ABSTRACT

Increasingly regulators are turning to market based incentive programs to meet environmental goals. For this reason, emissions trading programs are becoming more and more prevalent. Emissions trading programs can provide pollution prevention and air quality engineers with a new economic basis to justify pollution prevention projects.

This paper will outline the various types of emissions trading programs including off-set trading, open market trading and the various allocation trading programs including RECLAIM, and sulfur dioxide trading. We will also show how these programs can be used to justify pollution prevention projects.

Until recently Federal Facilities could not retain the revenues of emission trading programs. However, recent legislation now allows Federal Facilities to retain the revenues for environmental programs and other operating costs. This paper will outline the procedures for trading emissions and retaining the revenues to off-set environmental program costs.

INTRODUCTION

Emissions trading programs have been promoted as ways to use market mechanisms to achieve compliance. With Congress being increasingly critical of the Environmental Protection Agency's (EPA's) command and control approaches to compliance, market based approaches will continue to play a more important role in new air quality compliance strategies.

Besides playing increasingly greater roles in achieving compliance, these programs could give pollution prevention (P2) planning an added boost by providing additional financial incentives. Recent changes in Federal Law and Department of Defense (DoD) regulations now allow facilities to use the income from emissions trading programs to help pay for the installation environmental compliance costs.

TYPES OF EMISSIONS TRADING

The Clean Air Act (CAA) specifically mentions emissions trading provisions in Title IV, which governs sulfur dioxide emissions from the combustion of sulfur containing fuels, and in the emission offset provisions of the New Source Review Rules established under Title I. Trading provisions are also included in the implementing regulations for Title VI which governs ozone depleting chemicals. They are also being used frequently as a strategy in local rules and regulations necessary to reach attainment set forth in Title I. All of these trading provisions promote P2 because they create a value for the emissions. However, each of these emissions trading provisions is uniquely executed and also creates disincentives1.

New Source Trading and Banking

This is the oldest and most established of the emission trading programs. In this program banked emissions can be used to offset emission increases caused by new or modified sources. Banking may take place whenever there is a downturn in production, installation of new pollution control equipment that reduces emissions beyond what is required by existing rules or regulations, or

equipment that reduces emissions beyond what is required by existing rules or regulations, or whenever there is a process change or material substitution that will decrease emissions. Offset trading and banking is particularly important in ozone (smog) non-attainment areas because without these programs businesses in these areas could not increase emissions2. As the new ozone standard is implemented this program is likely to have increased application. Typically only trading within a state and usually only within an air basin is allowed, however trades can be made across basin3 and state lines4. Emissions must be5:

Surplus, meaning that the reductions are not required by other regulations,

Real, meaning that the reductions have already occurred and that production will not lead to an increase elsewhere in the air basin,

Quantifiable, meaning that the reductions can be measured,

Enforceable, meaning that violations can be enforced by the agencies allowing the trade, and

Permanent, meaning that the reductions will continue in perpetuity.

For P2 projects it may be difficult to prove many of these; for instance a substituted product may have a lower VOC content, but if more of the product is needed there may not be a permanent reduction in emissions. If an installation stops doing a particular operation, but the operation will be transferred to somewhere else in the same air basin, the reductions are not real and are therefore not bankable. An important note to consider is that any grandfathered emission sources (sources that did not have to meet current standards) will have to be brought up to current standards during base closures and realignment. This fact is easily overlooked.

Emissions can be reduced five ways whenever they are banked or traded:

If a new Reasonably Available Control Technology (RACT) standard is planned to go into effect for the equipment being retired or replaced, the actual emissions credit could be decreased by the expected reduction which would be expected from the new technology. This is because the emissions are not considered surplus.

When emissions are being taken out of the "bank" for a new or modified source, they may again be eroded by the expected emissions reductions that could come from RACT requirements on the new equipment. Again the emissions are not considered surplus in this case.

Depending on the attainment status of the local air basin, emissions are further eroded by the off-set ratio for the pollutant of concern. This is a requirement of offsetting.

The traded actual emissions must be sufficient to cover the potential emissions of the new or modified source. This is because the emission reductions must be real (only reductions in actual emissions can be considered real), and when they are applied to the new project they must be permanent (meaning there must be permit or physical limitations to ensure the potential emissions will not be greater than what came out of the bank).

Finally, if trading across air basin lines is allowed (which it usually is not), the emissions will be further eroded to account for the impact of the traded source on the air basin of the new source. California is one of the few areas where new source trades are allowed across air basin lines3 even though ground-level pollution crosses air basin lines elsewhere as well6.

Despite these disadvantages, the NSR emissions trading provisions usually allow for inter-pollutant trading, i.e. NO_2 emissions can be used for a new Volatile Organic Compound (VOC) source because both pollutants contribute to ground level ozone.

By creating a value for decreased emissions, these trading provisions give facilities a significant incentive for pursuing P2 projects.

Allocations Trading

There are three basic allocation trading programs currently in place; Sulfur Dioxide (SO2) Trading, Ozone Depleting Chemicals (ODC) manufacturing capability trading, and the RECLAIM program in the South Coast Air Quality Air District (SCAQMD). The most active of these programs is the SO2 trading program. With the exception of the RECLAIM program these programs will have little impact on P2 decision making, and the RECLAIM trading will only affect those facilities in SCAQMD. However since this type of trading is likely to expand into other areas, some discussion of the programs is needed. One attractive feature of these programs as models for new emissions trading provisions is that they tend to have well developed markets with a well established market price.

SO2 Emissions Trading

Under Title IV of the CAA, facilities that have traditionally burned sulfur fuels can trade their allocation to other facilities across state lines7. This trading program is an allowance type program whereby named facilities are given an allotment that declines stepwise with time. Initially the allowances were determined based on the BTU rating of the power plants which burn sulfur containing fuel. This program is designed to give facilities time to add controls or modify equipment as the local market dictates. Facilities that lower their emissions early can reap economic benefits by trading their allotments. One unique feature of this trading program is that allocations not used in one year can be rolled over to increase the allowed emissions for the following year. In all other trading programs unused allocations cannot be rolled over. Since acid rain problems cross air basin and state lines it is reasonable and necessary to allow trading across these lines.

RECLAIM Emissions Trading

The South Coast Air Quality Management District (SCAQMD) has a different approach to NSR emissions trading called the Regional Clean Air Incentives Market (RECLAIM). RECLAIM establishes initial allocations for some non-attainment pollutants (NOx and SOx) for each facility in the air basin. These allocations decline with time. If a facility decreases the emissions early, these emissions can be banked for future use or traded to be used by other facilities. This has created a much more robust emissions trading market and encouraged emissions reductions8.

ODC Production Capability Trading

The regulations governing the phase-out of ODCs include elaborate trading provisions. Not only can one facility trade the production capability to another company, but they can also trade the manufacturing capability of one ODC for the production of another. In the latter case there are adjustments needed to account for differing ozone depleting potentials. In all the trades accomplished thus far there has been a one percent offset to ensure that round-offs do not lead to production being greater than allowed9. Since the problem is global, not local in extent there are no geographic adjustments.

Open Market Trading

Open market trading is a relatively new concept. It is very similar to offset trading except the emissions are not necessarily for use at new sources but can be used for short term increases in emissions caused by market conditions or for compliance. Each program is different, but generally the same requirements for the emissions to be surplus, real, quantifiable, enforceable and permanent apply. There are no offset requirements, though there usually are transaction penalties on the order of 10% of the emissions. The Office of Air and Radiation of the Federal EPA working in conjunction with the Ozone Transport Assessment Group (OTAG) has proposed requiring 22 states and the District of Columbia to adopt an open market trading rule based on

the model rule proposed in July of 199510, 11. This model rule allows for interstate trading of ozone precursor emissions (principally NOx). Many of the states have already initiated rule-making activities and some even have rules in place12, 13, 14). This is likely to be an extensive market and one in which Federal Facilities will take part in large measure.

ESTIMATING VALUE OF EMISSIONS

The key problem why emission credits have not traditionally been included in P2 decisions is the uncertainties in valuing emissions. The oldest of the emissions trading programs are the new source emissions banking and trading programs. Under these programs facilities have to relinquish a right to emit voluntarily. With all of the uncertainties involved a facility is far better off not banking emissions and instead keeping them in reserve to offset a contemporaneous emissions increase due to expanded operations or increased work load. The proposed Open Market Trading programs may change this situation considerably.

There are essentially three ways to calculate the value of an emissions credit. The first would be mandated costs. These would be costs established in regulation for such trades. The second best way to calculate the value of emissions is by looking at the value of previous trades. For example in a well established market such as the SO2 emissions market the value of credits is well established15. The third would be to use the costs for controls.

Most emissions trading markets are not well established and there is no established market price. In these instances it is useful to evaluate local market prices and possible trends, but you may also want to estimate the value based on the costs to comply with regulations. Most agencies evaluate regulatory options based on the costs for implementing the regulation. The value of a given pollutant can be estimated based on what is considered a reasonable cost of control under the Best Available Control Technology (BACT) program. The local air district should be able to provide this value. The value will vary greatly from air basin to air basin because it will be driven largely by what will be required in that local air basin to reach attainment of the NAAQS. However, it is important to note that the value of an emissions credit also should take into consideration the time-value of money. Emissions from sources that will soon come under a RACT standard need to be discounted. However, permanent reductions should be valued more, because the credits will be good year after year.

FEDERAL FACILITIES IMPLICATIONS

Until recently, federal facilities have not been able to retain the economic proceeds gained as a result of emissions trading programs. Facilities have only been able to benefit from trading transactions for purposes of industrial growth, that is, when old equipment is retired to allow for the installation of new equipment. Also, facilities in certain air basins that wished to increase operations were able to capitalize on emissions banked from closures of facilities within that same air basin. Now federal facilities have a new incentive to incorporate P2 measures at their facility.

On November 18, 1997 a law was passed under §351 of the FY98 DoD Authorization Act, which allows for a "pilot program to assess the feasibility and advisability of the sale of economic incentives of the reduction of emission of air pollutants attributable to a facility of military department."15. This means that federal facilities now have the opportunity to use the proceeds from sales at their installation instead of depositing proceeds to the US Treasury. The pilot program is only in effect for 2 years. As of the writing of this paper, procedures for implementation of the pilot program have been approved by the Deputy Assistant Secretaries of the Navy, Army, Air Force and the Staff Director of Environmental Safety and Policy of the

Defense Logistics Agency. Final authorization from Deputy Under Secretary of Defense, Sherri W. Goodman, is still pending. Ms. Goodman has stated that she feels it essential that the Services become astute in trading programs in light of expected changes resulting from the Kyoto Protocol (global warming). The request by the SSC for the pilot program was patterned after the changes made to the "Military Construction Codification Act17, which provides for the proceeds from the sale of recyclable materials to be retained by that facility which sells them via a "Qualified Recycling Program". Previous to this enactment, facilities were required to deposit the proceeds obtained from the sale of recyclable materials to the U.S. Treasury. This provided little incentive for facilities to recycle. Now that facilities can retain proceeds, recycling rates have continued to increase. In calendar year 1997 the recycling rate of 37% has been the highest ever in the Navy18. This success is attributed directly to incentives by installations to retain their proceeds along with other regulatory requirements. If the balance available to an individual facility is in excess of $2,000,000.00 the amount of that excess shall then be deposited to the U.S. Treasury.

Unfortunately, the cap Congress allowed for the air emissions trading program is only $500,000.00 for the entire DoD. Other requirements under the pilot program are: economic incentives can't be sold if needed for operational use or if they are attributable under closure or realignment of a military installation. Sales may be transacted similar to the way they are within industry such as through an air broker, listing in environmental trade letters, through the local air pollution control district and listing in local newspapers.

Similar to the requirements found in the Qualified Recycling Program, facilities must first use the proceeds from the sales of emissions on transactional costs, such as the costs a facility uses to identify, quantify, value or establish the air pollution emission reductions in order to create a marketable incentive. Transactional costs do not include the costs of new capital equipment or modifications or existing equipment which aid in the reduction of air pollution emissions or internal labor costs.

Reports will need to be made to the DoD Comptroller as to the air quality district where the incentives were sold; the pollutant amount, type and applicable year; the applicable time period and the type of economic incentive; the amount of sale proceeds; transactional costs and the balance remaining.

Once this is done, the proceeds are available for all programs, projects, and activities necessary for compliance with Federal environmental laws.

CONCLUSIONS

This paper has provided a brief overview of air emissions banking programs, some of the problems with these programs and how to value emissions. It is possible that emissions trading can be a powerful incentive for P2 as evidenced in Sulfur Dioxide Trading, New Source Trading and Banking and the RECLAIM programs. However, the strength of the market dictates how successful trading programs can be and certainly trading can be a difficult navigation through requirements. The DoD program is fairly straightforward, however facilities will need to become more aware of the trading principles outlined in this paper if they are to be successful. The fact that the entire DoD cannot retain proceeds above $500,000 is too restrictive. The reason Congress has been so limiting is because funds have been specifically appropriated to facilities, and facilities should not have "increased" funds above what they are specifically appropriated. This is not realistic, however, because facilities often find funding for environmental compliance difficult to obtain. Coordination between installations will be difficult and the cap could easily

be met without realizing it. It's important the SSC continue to lobby for the cap to be increased and be unique to a particular service, for example, at least $1,000,000 per service. The SSC will also need to lobby to have the pilot program extended beyond the current deadline in order for the Services to finally experience the intent of the program: "to further reduce air pollution through creation of economic incentive strategies." Facilities need to trade effectively to prove the worth of the program and as October 1, 1999 looms closer it's imperative that facilities be fully prepared to take advantage of the program once signed by Ms. Goodman.

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RESOLVING ENFORCEMENT ACTIONS/FINES/PENALTIES THROUGH P2 SUPPLEMENTAL ENVIRONMENTAL PROJECTS (SEPs)

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INTRODUCTION

The Department of Defense (DoD) and the United States Air Force (USAF) have established environmental programs to ensure achievement of full compliance with laws and regulations of the United States (US) and the states in which their facilities are situated. To this end, the USAF makes large investments, millions of dollars annually, supporting environmental compliance. However, despite these investments, enforcement actions (EAs) and fines/penalties have continued to be issued. In reality, no matter how proactive your environmental compliance program is you are subject to enforcement actions and fines/penalties. If a regulatory inspector looks hard enough he or she can find something to write up. Let's face it, the regulators are employed to enforce the laws of the US.

USAF installations have made tremendous progress in reducing the number of open enforcement actions (OEAs) and preventing new ones. For example, the USAF has reduced their OEAs from two hundred ten in the fourth quarter FY93 to ten at the end of the second quarter FY98. The Air Combat Command (ACC) has had similar success. ACC had sixty-nine OEAs in FY92/2 and on 13 Apr 98 had reduced the number to zero. The Air Force and ACC have also done very well in preventing enforcement actions, for example, during the period of 1 Apr 96 - 31 Mar 97 the Air Force received eighty-two new violations (ACC - thirty-seven). The Air Force and ACC did much better during the period of 1 Apr 97 - 31 Mar 98, for an example, the Air Force received sixty-one new violations (ACC - eight). However, ACC and Air Force leadership understands now is not the time to become lackadaisical, but to keep environmental compliance (EC) a high priority. These leaders recognize the regulators consider EC a top priority and stand ready to enforce regulatory requirements. Why?

WAIVER OF SOVEREIGN IMMUNITY

In 1992 the Federal Facility Compliance Act (FFCA) was amended to reflect a waiver of sovereign immunity for federal facilities for Resource Conservation and Recovery Act (RCRA) solid/hazardous waste violations. Shortly thereafter, there was a waiver of sovereign immunity for Safe Drinking Water Act (SDWA) violations. In addition, in recent months there has been an increase of states challenging (in court) federal facilities sovereign immunity for Clean Air Act (CAA) and RCRA underground storage tank (UST) fines/penalties. As of 31 Mar 98 the

USAF had been assessed fines/penalties totaling $ 2,138,574 (ACC $330,743). The majority of these fines were negotiated to a lesser amount (USAF $637,321 (ACC $152,877)). The good news story here is the Air Force and ACC were successful in further negotiating Supplemental Environmental Projects (SEPs) or perhaps better known as "Payment in Kind" in lieu of paying fines/penalties. As of 31 Mar 98, the Air Force had negotiated SEPs totaling $444,764 (ACC $92,219). It is important to note here, payment for fines/penalties must come from the operations and maintenance (O&M) accounts of the organizations that were responsible for the violation and not from environmental compliance funds. However, environmental compliance or P2 funds (if available) can be used to correct the situation that caused the violations. EPA generally follows these criteria in exercising its discretion to establish an appropriate settlement penalty:

- Economic benefit associated with the violations
- Seriousness of the violations
- Prior history of violations
- Evidence of a violators commitment and ability to perform a SEP
- All else being equal, the final settlement penalty is normally lower for a violator that agrees to perform an acceptable SEP compared to the violator that does not agree to perform a SEP.

TAKING THE STICK

Environmental compliance issues and concerns are becoming more complex, and with the current downsizing and dwindling environmental resources it is more important now than ever for base leadership and environmental managers to "take the stick" and provide environmental stewardship in all areas of environmental compliance. Using P2 SEPs to resolve fines/penalties is surely one of the keys to placing funds in the appropriate area of "Flying Airplanes." This paper outlines some of the EPA policy that sets forth the types of projects that are permissible as SEPs, the migration appropriate for a particular SEP, and terms and conditions under which they may become part of a settlement.

BACKGROUND

In settlement of environmental enforcement cases, the US Environmental Protection Agency (EPA) requires that alleged violators achieve and maintain compliance with federal government laws and regulations and in most cases pay civil penalties. As mentioned before, the Air Force is also subject to paying civil penalties in those situations where sovereign immunity has been waived. In certain instances EPA allows environmentally beneficial projects or SEPs to be included as part or all of the settlement. In settling enforcement actions, EPA requires the alleged violators to promptly cease the violation and, to the extent feasible, remediate any harm caused by the violation. EPA and applicable states may also seek substantial monetary penalties in order to deter noncompliance. The concept here is without regulatory authority to assess penalties, companies and federal facilities would have an incentive to delay compliance until they are caught and ordered to comply. EPA uses penalties to ensure a level national playing field by ensuring that violators do not obtain an unfair economic advantage over their competitors who made the necessary payments to comply within the allotted time. One could argue this concept does not work with one federal agency assessing penalties against another.

However, remember that payment for fine/penalties are paid from the O&M accounts of the organizations that cause the violation. With this in mind, wing commanders get terribly upset when they have to use their resources that were provided to fly airplanes and maintain the base to pay for enforcement action violations. Fines/penalties should also encourage companies and the Department of Defense (DoD) facilities to adopt P2 techniques so they minimize their pollutant discharges, therefore, reducing their potential liabilities.

POLLUTION PREVENTION ACT

The Pollution Prevention Act of 1990 identified an environmental management hierarchy in which pollution should be prevented or reduced whenever feasible. In addition, pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible. Furthermore, pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible and disposal or release into the environment should be employed only as a last resort. Bottom line is, preventing pollution before it is created is preferable to trying to manage, treat, or dispose of it after it is created. P2 SEPs should be conducted in accordance with this hierarchy of environmental management. As you might imagine, SEPs involving P2 technology are preferred over other types of reduction or control strategies. Therefore, the use of a P2 SEP is reflected in the degree of consideration accorded to a violator before calculation of the final monetary penalty. Since P2 SEPs offer the most potential for a 100% mitigation of SEP costs, federal facilities should, whenever possible, propose effective P2 initiatives.

EPA REVISED SEP POLICY 1 MAY 98

Based on experience gained implementing the Interim Revised SEP Policy on 10 May 95, EPA has refined and clarified their SEP policy to better assist them in exercising its enforcement discretion to establish appropriate settlement penalties and SEPs. The refinements and clarification are illustrated in the new EPA SEP policy effective 1 May 98. This policy supersedes the May 95 Interim Revised SEP Policy. The basic structure and operation of the policy remains unchanged. The primary purpose of the SEP policy is to obtain environmental and public health protection and improvements that may not otherwise have occurred without the settlement incentives provided by the policy. The final policy retains the 1995 framework for determining whether a proposed project can be considered in establishing an appropriate settlement penalty. In addition, the policy also sets out clear legal guidelines; well-defined categories of acceptable projects; and simple, easy-to-apply rules for calculating and applying the cost of a SEP in determining an appropriate settlement penalty. The most significant changes made to the 1995 Interim Revised Policy include

- Explicit encouragement of community input into the development of SEPs in appropriate cases
- A prohibition on using SEPs to mitigate claims for stipulated penalties except in extraordinary circumstances
- The creation of an "other" category, under which projects that do not fit within a defined category of the EPA SEP policy but otherwise meet all other criteria of the SEP policy may be approved under certain procedural requirements

QUALIFYING FOR A SEP

In evaluating a proposed project to determine if it qualifies as a SEP and then determining how much penalty mitigation is appropriate, regulatory officials normally use the following five-step process:

- Ensure that the project meets the basic definition of a SEP
- Ensure that all legal guidelines, including nexus, are satisfied
- Ensure that the project fits within one (or more) of the designated categories of SEPs
- Determine the appropriate amount of penalty mitigation
- Ensure that the project satisfies all of the implementation requirements and other criteria

All five steps are discussed in detail in this paper. Additional information can be found in the Federal Register Volume 63, Number 86, Tuesday, May 5, 1998 (Final EPA Supplemental Projects Policy Issued).

DEFINITION AND CHARACTERISTICS OF A SEP

SEPs are defined as environmentally beneficial projects that a violator agrees to undertake in settlement of an enforcement action but the violator is not otherwise legally required to perform. Key parts of the SEP definition are illustrated as follows

- <u>Environmentally beneficial means</u>: A SEP must improve, protect, or reduce risks of public health or the environment at large. While in some cases a SEP may provide the alleged violator with certain benefits, there must be no doubt that the project primarily benefits the public health or the environment.
- <u>Settlement of an enforcement action means</u>: The regulatory agency has the opportunity to shape the scope of the project before it is implemented and the project is not commenced until after the regulatory agency has identified a violation.
- <u>Not otherwise legally required to perform means</u>: The SEP is not required by any federal, state, or local law or regulation. In addition, the SEP cannot include actions that the violator may be required to perform as injunctive relief as part of a settlement or order in another legal action, or by state or local requirements.

<u>NOTE</u>: SEPs may include activities which the violator becomes legally obligated to undertake two or more years in the future, if the project will result in the facility coming into compliance earlier than the deadline. Such "accelerated compliance" projects are not allowable, however, if the regulation or statute provides a benefit (e.g., a higher emission limit) to the violator for early compliance. The approval and performance of a SEP reduces neither the stringency nor timeliness requirements of federal, state, or local statues or regulations. And, of course, the performance of a SEP does not alter the violator's responsibility to rectify a violation expeditiously and return to compliance.

LEGAL RESPONSIBILITIES

Regulatory agencies, as well as federal facilities, have certain legal parameter that must be addressed when considering a SEP. To this end, the legal evaluation of whether a proposed SEP is within the Air Force's authority and consistent with all Constitutional requirements may be a complex task. Signed settlement agreements commit a violator to timelines and resources that must be honored. Involving legal counsel early in the SEP process is imperative.

SEP CATEGORIES

EPA has identified eight specific categories of projects that may qualify as SEPs. With the revised EPA SEP policy on 1 May 98, there was the creation of an "other" category, under which projects that do not fit within a defined category of the EPA SEP policy but otherwise meet all other criteria may be approved under certain procedural requirements.

The primary focus of this paper is on P2 SEPs. However, if you have a fine/penalty situation and it does not qualify for a P2 SEP, you are encouraged to the use one of the other categories. A proposed project must satisfy at least one of the following categories:

- **Pollution Prevention**: A pollution prevention project is one which reduces the generation of pollution through "source reduction," i.e., any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise being released into the environment, prior to recycling, treatment, or disposal. Note however after the pollutant or waste stream has been generated, pollution prevention is no longer possible and the waste must be handled by appropriate recycling, treatment, containment, or disposal methods. Source reduction may include equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, inventory control, or other operation and maintenance procedures. P2 also includes any project that protects natural resources through conservation or increased efficiency in the use of energy, water, or other materials. "In-process recycling," wherein waste materials produced during a manufacturing process are returned directly to production as raw materials on site, is considered a pollution prevention project. In all cases, for a project to meet the definition of pollution prevention, there must be an overall decrease in the amount and/or toxicity of pollution released to the environment, not merely a transfer of pollution among media. This decrease may be achieved directly or through increased efficiency (conservation) in the use of energy, water, or other materials. This is consistent with the Pollution Prevention Act of 1990 and the EPA Administrator's "Pollution Prevention Policy Statement" (New Directions for Environmental Protection), dated June 15,1993)

- **Pollution Reduction**: If the pollutant or waste stream already has been generated or released, a pollution reduction approach--which employs recycling, treatment, containment, or disposal techniques--may be appropriate. A pollution reduction project is one that results in a decrease in the amount and/or toxicity of any hazardous substance, pollutant, or contaminant entering any waste stream. This may include the installation of more effective

end-of-process control or treatment technology, or improved containment, or safer disposal of an existing pollutant source. Pollution reduction also includes "out-of-process recycling," wherein industrial waste collected after the manufacturing process and/or consumer waste materials are used as raw materials for production off-site.

- **Pollution Prevention Assessments**: Are systematic, internal reviews of specific processes and operations designed to identify and provide information about opportunities to reduce the use, production, and generation of toxic and hazardous materials and other wastes. To be eligible for SEPs, such assessments must be conducted using a recognized pollution prevention assessment or waste minimization procedure to reduce the likelihood of future violations. Pollution prevention assessments are acceptable as SEPs without an implementation commitment by the violator. Implementation is not required because drafting implementation requirements before the results of an assessment are known is difficult. Further, many of the implementation recommendations may constitute activities that are in the violator's economic interest.

- **Public Health** : A public health project provides diagnostic, preventative, and/or remedial components of human health care which is related to the actual or potential damage to human health caused by the violation. This may include epidemiological data collection and analysis, medical examinations of potentially affected persons, collection and analysis of blood/fluid/tissue samples, and medical treatment and rehabilitation therapy. Public health SEPs are acceptable only where the primary benefit of the project is the population that was harmed or put at risk by the violations.

- **Environmental Restoration and Protection**: An environmental restoration and protection project is one that enhances the condition of the ecosystem or immediate geographic area adversely affected. These projects may be used to restore or protect natural environments (such as ecosystems) and man-made environments, such as facilities and buildings. This category also includes any project that protects the ecosystem from actual or potential damage resulting from the violation or improves the overall condition of the ecosystem. Examples of such projects are

  - If EPA lacks authority to require repair of the damage caused by the violation, then repair itself may constitute a SEP
  - Simply preventing new discharges into the ecosystem as opposed to taking affirmative action directly related to preserving existing conditions at a property would not constitute a restoration and protection project but may fit into another category such as pollution prevention or pollution reduction
  - Restoration of a wetland in the same ecosystem along the same avian flyway in which the facility is located or purchase and management of a watershed area by the violator to protect a drinking water supply where the violation (e.g., a self- reported violation) did not directly damage the watershed but potentially could lead to damage due to unreported discharges.
    - This category also includes projects which provide for the protection of endangered species (e.g., developing conservation programs or protecting habitat critical to the well-being of a species endangered by the violation).

In some projects where a violator has agreed to restore and then protect certain lands, the question arises as to whether the project may include the creation or maintenance of certain recreational improvements, such as hiking and bicycle trails. The costs associated with such recreational improvements may be included in the total SEP cost provided they do not impair the environmentally beneficial purposes of the project and they constitute only an incidental portion of the total resources spent on the project. In some projects where the parties intend that the property be protected so that the ecological and pollution reduction purposes of the land are maintained in perpetuity, the violator may sell or transfer the land to another party with the established resources and expertise to perform this function, such as a state park authority. In some cases, the U.S. Fish and Wildlife Service or the National Park Service may be able to perform this function. With regard to man-made environments, such projects may involve the remediation of facilities and buildings, provided such activities are not otherwise legally required. This includes the removal/mitigation of contaminated materials, such as soils, asbestos and lead paint, which are a continuing source of releases and/or threat to individuals.

- **Assessments and Audits**: If they are not otherwise available as injunctive relief, are potential SEPs under this category. There are three types of projects in this category, Pollution Prevention Assessments, Environmental Quality Assessments, and Compliance Audits. These assessments and audits are only acceptable as SEPs when the defendant/respondent agrees to provide EPA with a copy of the report. The results may be made available to the public, except to the extent they constitute confidential business information pursuant to 40 CFR part 2, subpart B.

  - **Pollution Prevention Assessments**: Are systematic, internal reviews of specific processes and operations designed to identify and provide information about opportunities to reduce the use, production, and generation of toxic and hazardous materials and other wastes. To be eligible for SEPs, such assessments must be conducted using a recognized pollution prevention assessment or waste minimization procedure to reduce the likelihood of future violations. Pollution prevention assessments are acceptable as SEPs without an implementation commitment by the violator. Implementation is not required because drafting implementation requirements before the results of an assessment are known is difficult. Further, many of the implementation recommendations may constitute activities that are in the violator's own economic interest.

  - **Environmental Quality Assessments**: Are investigations of the condition of the environment at a site not owned or operated by the violator or the environment impacted by a site or a facility regardless of whether the site or facility is owned or operated by the violator. Also includes threats to human health or the environment relating to a site or a facility regardless of whether the site or facility is owned or operated by the violator. These include, but are not limited to, investigations of levels or sources of contamination in any environmental media at a site, or monitoring of the air, soil, or water quality surrounding a site or facility. To be eligible as SEPs, such assessments must be conducted in accordance with recognized protocols, if available, applicable to the type of assessment to be undertaken. Expanded sampling or monitoring by a violator of its own

emissions or operations does not qualify as a SEP to the extent it is ordinarily available as injunctive relief. Environmental Quality Assessment SEPs may not be performed on the following types of sites:

- Sites that are on the National Priority List under CERCLA, section 105, 40 CFR, part 300, appendix B
- Sites that would qualify for an EPA removal action pursuant to CERCLA, section 104 (a), and the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR, part 300.415
- Sites for which the violator or another party would likely be ordered to perform a remediation activity pursuant to CERCLA, section 106; RCRA, section 7003; RCRA 3008(h); CWA ,section 311; or another federal law

➢ **Environmental Compliance Audits:** Are independent evaluations of compliance status with environmental requirements. Credit is only given for the costs associated with conducting the audit. While the SEP should require all violations discovered by the audit to be promptly corrected, no credit is given for remedying the violation since persons are required to achieve and maintain compliance with environmental requirements. In general, compliance audits are acceptable as SEPs only when the violator is a small business or small community.

➢ **NOTE**: These assessments and audits are only acceptable as SEPs when the violator agrees to provide EPA with a copy of the report. The results may be made available to the public, except to the extent they constitute confidential business information pursuant to 40 CFR, part 2, subpart B. **Based on current Air Force and ACC policy, it is important to point out here, audits such as Internal and External Environmental Compliance and Management Program (ECAMP) are not releasable to regulatory agencies.**

- **Environmental Compliance Promotion**: An environmental compliance promotion project provides training or technical support to other members of the regulated community to

  ➢ Identify, achieve, and maintain compliance with applicable statutory and regulatory requirements or

  ➢ Go beyond compliance by reducing the generation, release or disposal of pollutants beyond legal requirements. For these types of projects, the violator may lack the experience, knowledge, or ability to implement the project itself, and, if so, the violator should be required to contract with an appropriate expert to develop and implement the compliance promotion project.

  ➢ Acceptable projects may include, for example, producing a seminar directly related to correcting widespread or prevalent violations within the violator's economic sector.

  ➢ **NOTE**: Environmental compliance promotion SEPs are acceptable only where the primary impact of the project is focused on the same regulatory program requirements which were violated and where EPA has reason to believe that compliance in the sector would be significantly advanced by the proposed project. For example, if the alleged

violations involved Clean Water Act pretreatment violations, the compliance promotion SEP must be directed at ensuring compliance with pretreatment requirements.

- **Emergency Planning and Preparedness**: Project provides assistance--such as computers and software, communication systems, chemical emission detection and inactivation equipment, HAZMAT equipment, or training--to a responsible state or local emergency response or planning entity. This is to enable these organizations to fulfill their obligations under the Emergency Planning and Community Right-to-Know Act (EPCRA) to collect information to assess the dangers of hazardous chemicals present at facilities within their jurisdiction, to develop emergency response plans, to train emergency response personnel, and to better respond to chemical spills. EPCRA requires regulated sources to provide information on chemical production, storage, and use to State Emergency Response Commissions (SERCs), Local Emergency Planning Committees (LEPCs), and Local Fire Departments (LFDs). This enables states and local communities to plan for and respond effectively to chemical accidents and inform potentially affected citizens of the risks posed by chemicals present in their communities, thereby enabling them to protect the environment or ecosystems which could be damaged by an accident. Failure to comply with EPCRA impairs the ability of states and local communities to meet their obligations and places emergency response personnel, the public, and the environment at risk from a chemical release. Emergency planning and preparedness SEPs are acceptable where the primary impact of the project is within the same emergency planning district or state affected by the violations and EPA has not previously provided the entity with financial assistance for the same purposes as the proposed SEP. Further, this type of SEP is allowable only when the SEP involves non-cash assistance and there are violations of EPCRA, or reporting violations under CERCLA section 103, or CAA section 112(r), or violations of other emergency planning, spill, or release requirements alleged in the complaint.

- **Other Types Of Projects**: Projects determined to have environmental merit which do not fit within at least one of the seven categories above but that are otherwise fully consistent with all other provisions of the EPA SEP policy may be accepted with the advance approval of the EPA Office of Enforcement and Compliance Assurance.

PROJECTS WHICH ARE NOT ACCEPTABLE AS SEPS:

The following are examples of the types of projects that are not allowable as SEPs:

- General public educational or public environmental awareness projects, e.g., sponsoring public seminars, conducting tours of environmental controls at a facility, promoting recycling in a community
- Contributions to environmental research at a college or university conducting a project, which, though beneficial to a community, is unrelated to environmental protection, e.g., making a contribution to a nonprofit, public interest, environmental, or other charitable organization, or donating playground equipment studies or assessments without a requirement to address the problems identified in the study

- Projects which the violator will undertake, in whole or part, with low-interest federal loans, federal contracts, federal grants, or other forms of federal financial assistance or non-financial assistance (e.g., loan guarantees)

IN CONCLUSION

Given the dynamic nature of environmental legislation and regulations, as well as the seemingly growing staff of state and federal EPA enforcement offices, we must do our home work like we have never done before. Again, we must continue to have proactive compliance programs and not just when the phone rings telling us that the regulatory inspectors are at the front gate. Why? Because as federal facilities we need to establish the benchmark for environmental compliance in the United States and because it is "the right thing do." The threat for enforcement by regulatory agencies is real and the need for establishing and maintaining a method of off-setting cost of fines/penalties imperative. You are encouraged to use the P2 SEP tool to achieve environmental compliance and prevention of enforcement action, fines, and penalties. Downsizing and budget reduction is here to stay. To this end, using P2 initiatives to achieve compliance is the way to do business for years to come.

Why P2?

Pollution prevention solutions provide a proactive means of dealing with compliance requirements and produce long-term cost benefits. This approach is preferred over more costly treatment technologies, regulatory reporting, and disposal procedures. It is Air Force policy to use P2 as the first choice to meet new legal requirements and to ensure adherence with existing compliance requirements. Accordingly, the Air Force set a goal of transferring 20 percent of the EC budget to P2 by FY03.

The challenge is that compliance requirements have not gone away. To the contrary, we now find that even with the Air Force's great success in environmental management, the regulatory requirements have more than kept pace. Standards for compliance are becoming more restrictive. In late 1997, for example, new federal regulations on air emissions were announced, making it difficult for most bases to avoid enforcement actions without taking decisive action. In response to such changes, we must look for P2 solutions to our EC problems. It is a "Force Multiplier."

REFERENCES

1. Federal Register Volume 63, Number 86, Tuesday, May 5, 1998
2. ACC Environmental Quality Handbook, 5 Sep 97

Session VI
P^2 In Painting Operations

Session Chairpersons:

Mr. Bob Fredrickson, NFESC
Mr. Dave Leeson, SA-ALC/EMP

ISSUES IDENTIFIED DURING THE AETC AIRCRAFT PAINT REGIONALIZATION STUDY

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ABSTRACT

The 1990 passage of the Clean Air Act Amendments applied new emission requirements to several source categories of Hazardous Air Pollutants (HAPs). The National Emission Standards for Hazardous Air Pollutants (NESHAP) for Aerospace Manufacturing and Rework Facilities, commonly called Aerospace NESHAP, raised concern in the Air Force that major aircraft paint facility modifications may be necessary. The question the Air Education and Training Command (AETC) Logistics staff wanted answered was "What requirements will be imposed on our aircraft maintenance facilities to bring them into compliance with the new rule?"

The Headquarters AETC Logistics and Civil Engineering offices set out to work together to clarify the command requirements. A three-prong approach was used. (1) Update the command base air emission inventories for stationary sources using the latest regulatory guidance. (2) Evaluate all base level paint and depaint facilities in addition to all maintenance operations using volatile organic solvents. Finally, (3) perform an operational needs analysis using lifecycle cost business method to evaluate alternative solutions.

The ongoing Environmental Protection Agency regulatory clarifications and the continuing evaluation of AETC painting operations led to the eventual narrowing of the required compliance actions. During the course of the aircraft corrosion control facility analysis AETC began identifying whether adequate capacity existed for current aircraft corrosion control maintenance requirements. The aircraft painting capacity analysis identified that a capacity shortfall existed, but had never been identified by the base level corrosion shops. An Audit Agency review of the AETC plastic bead blasting facilities identified an excess of capacity. The challenge became how to find the most economical solution to satisfy the operational requirements.

Background

The Clean Air Act (CAA) amendment for Aerospace NESHAP focused on aircraft maintenance operations that worked on the exterior flight supporting parts of aircraft and space vehicles. The specific operations within AETC that would be affected were aircraft painting, de-painting and general solvent usage, such as in wipe-down or surface cleaning operations. The Aerospace

NESHAP applies to facilities that are a major source of HAPs. The details of the Aerospace NESHAP rule may be found in 40 CFR 63 Subpart GG (40 CFR 63.741 – 63.753). A good summary of the rule may be found in the Pro-Act Fact Sheet, National Emission Standards for Hazardous Air Pollutants (NESHAP) for Aerospace Facilities, June 1997.

When the rule was first proposed as published in the federal register in June 1994, it appeared that it might apply to all AETC aircraft corrosion control operations and all solvent usage in any base shop. Further EPA clarification limited the solvent usage coverage to just the aircraft maintenance operations. Early estimates for AETC compliance with the rule placed the command cost at $22.9M for building or modifying 18 corrosion control facilities at ten bases. Review of the 1993 air emission inventories for AETC showed that 9 of 12 bases were major sources of HAPs based on their potential-to-emit pollutant emissions exceeding the threshold of 25 tons per year of HAPs. Based on this initial assessment the question for AETC became, 'What actions should AETC take to minimize the Aerospace NESHAP compliance costs?' HQ AETC assembled a command team to address AETC Aerospace NESHAP compliance.

Review of the available 1994 air emission inventories (AEI) HAP potential-to-emit (PTE) levels showed an increase from the 1993 AEIs. This could probably be attributed to minimal EPA guidance on how to calculate the PTE. In the first quarter of 1996 AETC contracted to have all the AETC base air emission inventories calculated for CY 1995. The 1995 AEIs showed that only four of the 13 AETC bases had exceeded the HAPs PTE major source threshold.

AETC's corrosion control facilities were 25 to 30 years old, since they had been built in the 1960s or 70s. Assuming the base aircraft paint booths had to convert to Aerospace NESHAP required VOC control and inorganic HAP filters, then it would be smart to identify all the facility deficiencies and requirements early. The AETC Aerospace NESHAP and facility review team visited the AETC bases concurrently with contractor team to collect and prepare the base air emission inventories. The facility review team looked at the paint booths for each regulatory requirement. All the paint booths looked at required some upgrade to bring them up to the current paint booth best achieveable control technology (BACT) standards.

Paint Conversion

In June 1997 HQ AETC/LGMTS sent out a message to the AETC base LGMs to begin conversion from high VOC paints and primers to low VOC products. The June 1997 message requested that all units identify to the HQ AETC Technology Support Section all paints and primers that the base is not aware of a suitable low VOC substitute. By December 1997 most high VOC aircraft paints and primers had suitable substitutes identified.

In December 1997 HQ AETC/LGMTS sent out a second message mandating conversion to all low VOC paints and primers. The message recommended using up remaining existing stocks of high VOC paints and primers. The message mandated that all AETC units begin using low VOC paints and primers by 1 March 1998. The message further requested that any units that would not be able to meet the 1 Mar 98 compliance date, forward identification information about the remaining materials and the projected date that such high VOC materials would be used up. One

of the goals of the conversion was to use up the remaining high VOC material stocks, without having to dispose of any of the high VOC materials as hazardous wastes.

By May 1998 all the AETC aircraft and support equipment corrosion control sections had successfully converted to low VOC paints and primers. Paint conversion for all of AETC was accomplished three months in advance of the Aerospace NESHAP compliance date of 1 September 1998. This was not a problem since AETC had already converted in previous years to high volume low-pressure (HVLP) spray guns. The HVLP guns were designed to be able to apply low VOC paints and primers.

Base Painting Capacity

The AETC Aerospace NESHAP compliance team talked with the corrosion control shop personnel and flight chief to determine the flight's workload capacity. Workload capacity initially was based on the quantity of staff members assigned, the number of daily work shifts, and the number of assigned aircraft or support equipment that must be maintained by each base aircraft corrosion control flight.

One of the things that the AETC team discovered was that simply looking at the aircraft paint workload from the perspective of number of personnel assigned to a function or the number of shifts worked by the assigned personnel was not a good indicator of the quantity of aircraft that could be moved through their aircraft corrosion control paint booth. It became apparent that neither of these factors was directly linked with the production capability of the base corrosion control shop.

So the team then identified that they did know several factors, but the question was how to relate them all together. The solution was to settle on a new workload capacity concept element the 'Flow Day'. The flow day was the number of days that an aircraft took to move through each base corrosion control facility from the start of work to the end of work. The flow days that each base took to perform the required corrosion control work was a calculated factor. The flow day was determined by the number of clock hours (chr) used at each location to perform all the required aircraft corrosion control work for each type of aircraft along with the number of days the aircraft was in the base corrosion control facility. At some bases corrosion control only worked 1-shift days (8 hrs), while others worked 2 shift days (16 hrs). Just because one base worked 2 shifts versus 1 shift, didn't mean that an aircraft work was done any sooner. In either case the aircraft took a finite number of days to prep, paint, cure, and perform final detail. The limiting factor in facility capacity was the number of days that the aircraft was in the facility. This number of work days per aircraft in the aircraft paint hangar was defined as the number of flow days for that aircraft in that base facility. The number of flow days required for each type of aircraft also varied by base. Apparently there was also variability in the local environmental conditions (temperature, humidity, etc.) and the workforce that caused this.

Based on the way AETC performs the flying training mission, it was decided that the number of available workdays in our facilities was 232 days per year. The base corrosion control aircraft workload typically consists of three operations: touch-up painting, mid-life scuff sand and

overcoat painting, and periodic full paints. The touch-up and maintenance painting occurs annually and as needed. The mid-life scuff sand and overcoat (SS&O) painting occurs mid-cycle in the aircraft paint cycle. Aircraft periodic full paint occurs at the end of the aircraft paint cycle. For example, at year three a SS&O and at year six a full paint/depaint are performed on a T-37. Some typical AETC aircraft paint cycles are shown in Table 1.

Table 1

	Operation		
Aircraft Type	**Touch-up**	**Scuff Sand &Overcoat Mid-cycle**	**Full Paint Full-cycle**
	Period		
T-37B	Annually – 1 yr	3 yr	6 yr
T-38	Annually – 1 yr	3 yr	6 yr
F-16	Annually – 1 yr	3 yr	6 yr
C-17	Annually – 1 yr	5 yr	10 yr
C-130	Annually – 1 yr	6 yr	12 yr
C-5	Annually – 1 yr	7 yr	14 yr

Table 2

Aircraft Type	**Quantity Assigned**		
T-37	98		
Corrosion Operations in Paint Booth/Hangar			
Operation Type	**Qty Jobs / Yr**	**Flowdays / Job**	**Flowdays / Yr**
Touch-up	20	2	40
SS&O	6	5	30
Full Paint	6	4	24
Total T-37 Workload Requirement			94

Table 3

Aircraft Type	**Corrosion Control Flowdays Required**
T-37B	94
T-38	90
T-1A	76
Aircraft Flowday Requirement	**260**
AGE / Support Equipment Req.	24
Base Flowday Requirement	**284**

The frequency of the corrosion control work along with the number of assigned aircraft defined the number of corrosion control operations required annually for each aircraft type. When you combine the number of flow days each operation takes per aircraft along with the number of required operations per aircraft type, then you get the facility flowday requirements for each aircraft type.

Add up the flowday requirements for each aircraft type and you get the base flowday requirements. An AETC undergraduate pilot training (UPT) base typically has multiple aircraft types assigned, such as T-37s, T-38s and T-1s. The base corrosion control requirements for such a mix of aircraft may look something like that shown in Table 3. An additional support

requirement that may use the aircraft corrosion control hangar is aerospace ground equipment (AGE) or other large support equipment. An example of the AGE or support equipment flowday requirement for the aircraft paint booth/hangar is also shown in Table 3.

The available workdays in any facility on base are 232 days as explained earlier. The base requirement in this example is 284 flowdays. Already this sample base has a shortage of 54 flowdays. In almost all cases each base in AETC had a capacity shortfall. So it was decided to identify several optional approaches to solve the AETC aircraft painting capacity shortfall..

Regionalization

A regionalization study was initiated to formalize the approaches that could be used to solve the AETC aircraft painting capacity shortfall. It was decided that six alternatives would be considered and assessed for their 25-year lifecycle cost. Table 4 shows the AETC regionalization study alternatives considered.

The objectives of the study were to find an alternative which would maintain/achieve regulatory compliance and meet the documented corrosion control workload. Alternative 1 could not meet these objectives, therefore, it was not considered for detailed evaluation. Alternative 2 determined that 13 new aircraft corrosion control facilities (paint bays) would be required. Alternative 3 determined that nine new aircraft corrosion control facilities (paint bays) would be required. See Table 5 for detailed capacity analysis and illustration of the new facility needs.

Alternative 4 to outsource to other USAF commands did not become a viable alternative, since, none of the other Air Force organizations contacted indicated having any available capacity or interest in the option.

Table 4

Alternative 1	Continue current aircraft corrosion control operations in available facilities	—
Alternative 2	Upgrade existing aircraft corrosion control facilities to achieve regulatory compliance and add new compliant facilities to meet documented workload at each installation	$179M
Alternative 3	Regionalize within AETC	$129M
Alternative 4	Maximize outsourcing AETC workload to other USAF commands	$218M
Alternative 5	Maximize outsourcing to commercial facilities	$187M
Alternative 6	HQ selected combination of alternatives 3, 4 and 5.	$112M

Alternative 5 to outsource to commercial facilities did not become a viable alternative due to lack of adequate response. Twenty-five companies were identified, but only seven were identified as having the capability, potential excess capacity, and interest in AETC requirements. The available excess capacity among the seven companies could not be determined. Only two companies were able to provide estimated costs and available capacity in compliant facilities. A solicitation response may be substantially more responsive.

Alternative 6 is the HQ AETC/LGM selected option. It is a variation of alternative three, since no source for outsourcing had been identified. A 25-year lifecycle cost assessment of each alternative was prepared. The preferred alternative based on total cost is alternative 3. Alternative 6 was not costed in the report due to implementation schedule options. The alternatives and cost may be found summarized in Table 4.

Table 5

Base	Facility Number	Number of Bays Existing	Number of Bays New	Capacity (fday/year)	AETC Workload Total (fday/year)	Capacity Excess/ Shortfall (+/-) (fday/year)
Altus	New Facility	NA	1	232	161	71
Columbus	Building 262 and New Facility	1	2	696	696	0
Kirtland	New Facility	NA	1	232	222	10
Laughlin	Building 51 and New Facility	1	2	696	698	-2
Little Rock	New Facility	NA	1	232	221	11
Luke	Building 922	2	NA	348	348	0
Randolph	Building 48	1	NA	232	232	0
	New Facility #1	NA	1	232	208	24
	New Facility #2	NA	1	232	226	6
Sheppard	Building 2402	1	NA	232	233	-1
Tyndall	Building 315	1	NA	232	231	1
Vance	Building 192	1	NA	232	232	0
Total		8	9	3,828	3,708	120

HQ AETC/LGM decided that it could only support the addition of a 2-bay paint hangar for small aircraft at Laughlin and Columbus AFBs and one medium-bay paint facility at Randolph AFB. The cost for these three projects is projected as shown in Table 6. Aircraft corrosion control workload would be regionalized at these facilities by moving aircraft from Vance, Sheppard, Luke, and Laughlin AFBs.

Table 6

Base	Type of Facility	MILCON Cost Est
Laughlin AFB	2-Bay Hangar (Small)	$4.8M
Columbus AFB	2-Bay Hangar (Small)	$4.8M
Randolph AFB	1-Bay Hangar (Medium)	$7.5M

In conclusion, the Regionalization Study was a beneficial planning tool for AETC. The team development of the aircraft corrosion control concept of the 'flowday' has become the key in corrosion control facility planning. This tool will allow for a much better understanding of the individual base requirements. The utilization of the 25-year facility present worth cost will more clearly define the true cost of business. The present worth cost of a facility allows the commander to make a more informed decision about the cost of adding a new facility. No longer is the decision solely based on the construction and design cost of a facility.

Reduction of Waste: A Profile of Success

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The 341 Transportation Squadron is continually searching for new ways to prevent pollution and reduce waste. Our biggest project to date has been the upgrading of the Allied Trades facility. The current facility has been in use since the early 1960's. Though this building was originally designed to be used by Boeing Corporation as a vehicle service station, some 30 years ago it was turned into an Allied Trades Shop for Malmstrom AFB. Obviously, this building was never designed for this purpose, and has been a poor substitute at best. In this time of down sizing, outsourcing, and base closures we decided to take a look at our building and our processes, we weren't impressed. We found numerous areas for improvement both environmentally and in element organization. After the eye-opening look we took at ourselves we put numerous initiatives into motion that will both improve our organization and lessen the impact that we have on the environment. One of these initiatives is a major facility renovation, due to be completed in mid 99, in addition we have purchased new equipment that will greatly enhance the element's work organization and ensure environmental compliance into the foreseeable future. A systems approach to incorporate state of the art technology has resulted in a 70% reduction in hazardous waste streams in this element. We are committed to providing the best equipment for our people and making it a priority to purchase equipment that reduces waste and is environmentally friendly. In order to get the full understanding of what we have been able to do, we will outline our improvements step-by-step.

The first item we will cover is the new paint guns we have acquired. They are the Sata jet HVLP(high volume low pressure) model B-NR 95. To get a full understanding of the improvements that this product has given us, we will discuss our old model's performance versus our new model. Our old paint guns were of the conventional siphon feed type, none of which were very efficient. These siphon feed type guns only have about a 35% transfer efficiency rate which led to large amounts of over spray and wasted paint. These types of paint guns utilize medium to high air pressure to atomize the paint once it leaves the spray tip, this creates excessive amounts of over spray. As an example, if 55 psi of air goes into the gun, the paint exits the gun and is atomized at 55 psi, resulting in low efficiency and over spray. Due to its 35% transfer efficiency(65% inefficiency), it takes as much as two times the paint to cover the same surface area as is

required with the Sata jet. With this poor transfer rate, significant amounts of over spray are released into the environment. While this is not the only reason for our over spray problem, it was a large part, other factors will be discussed later. The new Sata-jet paint guns have greatly improved the painting operations. These guns are of the gravity-fed HVLP type, which helps in several areas. For example, for every 10 psi that goes into the gun, 1 psi comes out. This alone greatly reduces the over spray, raising the transfer efficiency from 35% to 80%. The gravity fed design of the Sata jet gun allows for virtually all paint in the gun to be used, this reduces waste paint and greatly reduces clean up time. The HVLP design of the gun allows the paint to be atomized with far less air pressure. While the HVLP gun is a more technically advanced gun, the clean up of this particular model is far easier than that of a conventional gun. The paint cup is made of stainless steel which eases washing, there is no pick up tube to be cleaned, and because it is gravity fed, paint thinner can be cycled through the gun without any air pressure. This eliminates paint thinner being blown into the air, which reduces both worker and environmental exposure.

With new paint guns came the need for a better way to clean them without creating more of a waste stream and, possibly reducing it. This led to the purchase of the Herkules Paint Gun Washer and Recycler. This system allows us to do several things. First, it eliminates worker exposure to the solvents during cleaning operations. Second, it is self-contained, which reduces the amount of vapors released into the environment, while virtually eliminating the chance for a waste spill. The self contained design of the Herkules gun cleaner allows for less thinner to be used, as all thinner is re-circulated. This re-circulated thinner is used until it becomes too contaminated to clean effectively. This in itself has provided savings in both money and waste. The Herkules also has a larger capacity, this allows two guns to be cleaned at once. Our old system was one provided by a government contract. It required the workers to physically wash their guns as a stream of solvent was run across them. This put the workers in direct physical contact with the solvent, and within close proximity to the solvent fumes. The contractors system had to be vented, this released solvent vapors directly into the environment. With the old system, the contractor changed solvents approximately every 6 weeks, this resulted in at least 5 gallons of waste per visit. Since implementing the use of the of the new cleaner 12 weeks ago, we have yet to dispose of any thinner as waste. The Herkules system has also saved us money on the purchase of paint thinner, due to the fact we use shop recycled thinner as it's sole cleaning solvent. With the Herkules paint gun cleaner there was a one time start up fee of $35, and no waste produced. This is compared to the contractors system which has a $1,200 annual cost, and produces approximately 44 gallons of waste a year.

With the purchase of new paint guns and a new gun cleaner, we decided to look at another of our big waste producers, paint. With our old paint system we were using a low solids paint with a VOC (volatile organic compound) content of at least 5.2 pounds per gallon. We determined, through intensive research, that we could do much better. As a result of our research we purchased the PPG Delta Paint Mixing System. This system serves our needs in a variety of ways. First and foremost, it allows us to meet or exceed

some of the most stringent environmental regulations in the nation. Although there are currently no such regulations for VOC output in Montana, a national ruling that would set VOC maximums at 4.9 lb. per gallon is expected in the near future. With our Delta system, which is only 3.5 lb. per gallon, we exceed that level and levels for over 80% of the nation. If it becomes necessary, we can lower our VOC to 2.8 lb. per gallon. Lowering VOC contents to this level would put us in compliance with some of the most stringent regulations in the nation. Since the system uses a high-solids paint, it requires fewer coats to do the same surface area as our old system. High-solids paints are denser, this enables the workers to use half as much paint to cover the same surface area. Though there was a noted increase in the cost of the paint per gallon, by using half as much paint for the job there is not a noticeable end-cost increase, and in some instances there is a substantial decrease. This type of paint has proven to be just as durable and resilient as the previous paint. The clear coat has proven to be much more scratch resistant and has a higher gloss-back image than that of our old clear coat. With the new system we have noticed a marked decrease in paint procurement time, and less mixed paint sitting in stock. These decreases are due to the fact the paint toners are now on hand and readily available. This enables us to mix the paint color that we need in the quantity we need. With our old way of doing business we would need to go downtown, and purchase a minimum of 1 pint of paint, regardless of the size of the job. The left over paint would then be stored in a flammable locker, where it would often become waste. Another drawback to our old system was the wait time for the jobber from downtown to mix and deliver the paint. With this new system, we are able to mix the exact amount of paint we need for each job, as we need it, with no delay. This has virtually eliminated the wasted paint and excessive down time, and in theory gives us exact paint matches for repair work. The one problem we have had with this new system is due to the high solid content of the paints and not having the proper "paint codes" to mix the exact color. This has limited us in some instances where the representative from PPG has had to send a color example to the factory for a custom color blend. Other than the typical growing pains that come with any new process, the new system has halved our waste and improved the painting process in terms of end result. Although the system cost us $12,000 it has almost paid for itself in just over three months. The $12,000 price tag is minute when compared to the potential environmental savings.

Although all of our purchases have improved our way of doing business and reduced the impact we have on the environment, the jewel in our crown is the purchase of the "Recyclit" Thinner Recycler. This unique device virtually eliminates our liquid waste stream. With this system, the used paint thinner is distilled, this leaves clean thinner. This clean thinner can then be used as paint gun cleaning solvent. The small amount of solid waste is easily disposed. Waste can be dealt with in one of two ways, mixed with thinner and used as vehicle undercoating or simply dried and eliminated. A test is underway to determine if this solid waste can be disposed of with the normal trash. This system has been in use in our shop for just over three months, and we have yet to purchase new thinner. The need to purchase new gun cleaning solvent has been eliminated by the use of the Recyclit Thinner Recycler. Since implementing the use of

our new recycler, we have reduced our liquid waste from 16 gallons per month to zero. Because used thinner is continually added to the recycled thinner, this process can hypothetically go on indefinitely without having to purchase new thinner. This has not been tested at our shop yet due to the fact we have only been using this system for three months. We have seen significant reductions in our thinner purchases, as we were buying 16 gallons of thinner every 6 weeks at a cost of $182. Since the purchase of the Recyclit we now recycle 20 gallons of thinner every 6 weeks and our only cost is the sludge bags which are $5 each for every 5 gallons of thinner recycled. This system was paid for by the base's environmental flight at no cost to us. The savings to the Air Force is significant in terms of hard currency and in environmental areas. It previously cost $510 to dispose of one 16 gallon barrel of used paint thinner, whereas now, it costs nothing. The savings to the environment can not be measured in dollars. Since we no longer dispose of this type of waste, contamination/pollution problems are virtually eliminated.

Although we are proud of the improvements made to the Allied Trades Element, we realize that success is judged not only by the here and now, but also by our plan for the future. As stated earlier, our facility is severely limiting and has not met OSHA or Air Force standards for a number of years. After over 20 years of working in an inadequate facility, we have undertaken a major renovation project. With this project we will be completely renovating an existing building which is much larger and several years newer. In this new facility, we will be installing an Accudraft 2000 paint booth. Along with our new paint booth, we will be installing a ventilated paint mixing room, that will further reduce workers exposure to harmful vapors. These future plans also include the installation of Accudraft Prep Stations, these are currently in the research stage. Our current system for painting vehicles entails prep work in our body shop, painting is then done a quarter mile away in an undersized, poorly lit, inadequately ventilated, cinder block room which is now serving as our "paint booth." Some problems associated with this process include additional man hours transferring vehicles between buildings, more time to re-wash vehicles after the transfer, hazardous working conditions due to poor lighting and improper ventilation. While these problems are all significant, there is another problem that is just as pressing. That problem is the release of paint particulates into the environment. Our current filtration system is highly inadequate and allows paint over-spray to escape through the ventilation system. This is evidenced by the buildup of paint on the outside of the building under the ventilation ducts. With the completion of renovations our body shop will be self contained in its own building, all aspects of shop work can then be accomplished in one area to include painting and prep. With our new facility, we will be installing the Accudraft 2000 paint booth which will enormously reduce harmful outputs to the environment and limit exposure to the workers. This booth is large enough to handle 95% of our vehicle fleet. This alone will reduce contract costs. Currently, any vehicle larger than a crew cab pickup truck has to be sent downtown or to F. E. Warren AFB to be painted. The Accudraft system contains a duel exhaust filtration mode. With this improvement, it will trap more paint particulates preventing release into the environment. It also has an improved bake cycle which utilizes up to 80% re-circulated hot air. This is a more efficient system for a booth of this size. It utilizes 1.55 million BTUs/hr whereas the average system of this size will require 3 million BTUs/hr.

Not only does this system reduce the harmful releases into the environment, but it is also more energy efficient. With its unique exhaust system which utilizes four fans, each moving 11,000 CFM(cubic feet per minute), it will eliminate "dead spots" thus greatly reducing the chances for flash fires, and dull paint finishes due to trapped solvent.

Though Air Force body shops are unique due to the nature of our mission, we have shown through positive action that our shops can be comparable to civilian body shops. The improvements we have made will let us stay in step with the changing technology of today's automotive collision industry, while giving the government the highest quality product for its dollar. All of this can be done while still putting our environmental concerns and workers' health in the highest priority. So, in these days of lead, follow, or get out of the way, we at the 341 Transportation Squadron have decided to lead, let everyone else follow.

COMPARISON TESTING OF ENVIRONMENTALLY FRIENDLY CARC COATING SYSTEMS OVER ALUMINUM SUBSTRATES

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ABSTRACT

The Chemical Agent Resistant Coating (CARC) system is designed for application to many components on Army vehicles. Variations in the CARC system to reduce VOC and hazardous material usage are desirable from a cost standpoint. The Industrial Operations Command (IOC), through the supervision of the Centers of Technical Exchange (CTX) program, tasked Ocean City Research Corporation to complete an evaluation of the MIL-P-53030 water-reducible epoxy primer and the MIL-P-53022 solvent-based epoxy primer over chromate conversion coated (CCC) and non-CCC aluminum surfaces. In all, six accelerated performance tests and two physical properties tests were performed on twenty-six (26) different coating system combinations. This paper presents results and conclusions from the accelerated corrosion testing and natural marine weathering tests only. Variations in the performance of the CARC system were noted. The most significant variables affecting CARC system performance were the aluminum alloy tested and cleaning methods for the samples. Differences were observed, although minor, between the two primer formulations. The conclusions of this work demonstrate the feasibility of modifying the CARC system for some applications to better address environmental and worker health issues.

BACKGROUND

In 1995 Red River Army Depot (RRAD) implemented a revised process for applying the CARC system on 5000 series aluminum hulled vehicles. The process eliminated the need for chromate conversion coatings. The revised process called for garnet blasting to achieve a specified surface profile, cleaning with an aqueous cleaner, application of MIL-P-53022 epoxy primer, and application of the MIL-P-46168 polyurethane topcoat. A water-reducible epoxy primer (MIL-P-53030) is approved for use in the CARC system, but its performance has not be proven in the modified RRAD process for 5000 series aluminum. A new water-reducible polyurethane CARC coating is also being developed to help reduce depot VOC emissions. Also, the RRAD process has not been significantly examined for use with other aluminum alloys, such as 2000 series used for road wheels, 6000 series angle supports, or 7000 series for turret components.

The Industrial Operations Command (IOC), through the supervision of the Centers of Technical Exchange (CTX) program, tasked Ocean City Research Corporation to complete an evaluation of the MIL-P-53030 water-reducible epoxy primer over CCC and non-CCC aluminum surfaces. The long-term performance of the water-reducible epoxy primer has not been quantified in comparison to the solvent-based primer for the

modified RRAD coating process. The cost savings associated with environmental and worker protection measure reductions by using the water reducible primer can only be realized if the primer provides adequate CARC system durability.

OBJECTIVES

The short and long-term objectives of this study were to:

- Characterize any CARC system performance differences realized by using the MIL-P-53030 water reducible primer in place of the MIL-P-53022 solvent based primer.
- Investigate the applicability of the RRAD coating process for other aluminum alloys.
- Minimize the VOC produced by using the CARC system.
- Maintain Vehicle Readiness and Durability.

TECHNICAL APPROACH

The CARC specification, MIL-C-53072 "Chemical Agent Resistant Coating (CARC) System Application Procedures and Quality Control Inspection," dictates the use of four steps in the CARC coating system. The subject research investigated several CARC system variations over aluminum substrates. Table 1 identifies the approved processes and materials for the CARC system and shows the variables included in this program.

Table 1. MIL-C-53072 - CARC System over Aluminum Substrates

CARC System Step	Approved Processes and Materials	Test Variables
Cleaning	• TT-C-490 & MIL-T-704, Mechanical, Solvent, Emulsion, Vapor Degreasing	• Aqueous Alkaline Cleaner after Garnet Blast • Aqueous Alkaline Cleaner after Walnut Shell Blast
Pretreatment	• DOD-P-15328 & MIL-C-8514, Wash Primers • MIL-C-5541, Chromate Conversion Coating • MIL-A-8625, Anodizing	• MIL-C-5541, Chromate Conversion Coating • none
Primer	• MIL-P-23377, Chemical Resistant • MIL-P-53022, Solvent based • MIL-P-53030, Water reducible • MIL-P-85532, Low VOC	• MIL-P-53022, Solvent based • MIL-P-53030, Water reducible
Topcoat	• MIL-C-22750, epoxy Interior • MIL-C-46168, 2 component polyurethane • MIL-C-53039, moisture cure polyurethane • MIL-C-64159, water reducible 2 component polyurethane	• MIL-C-22750, epoxy Interior • MIL-C-53039, moisture cure polyurethane • MIL-C-64159, water reducible 2 component polyurethane

Four different aluminum alloys were selected for this testing. These were alloys 5086, 2024, 7075, and 6061. These or similar alloys comprise many of the vehicle components maintained at Army Depots.

Since the CARC coating system is designed for both aluminum and steel substrates it is important to note that aluminum alloys typically corrode at a rate 2 orders of magnitude less than steel. Among the alloys of aluminum, alloy 2024 has a corrosion rate more than twice that of 5086 and 6061. Knowing this, it would not be surprising to expect CARC corrosion performance differences among different metals or alloys.

Figure 1 shows the average maximum values for visual scribe cutback after six months of testing. The bars represent the maximum distance from the edge of the original scribe that corrosion has visually progressed under the film. All systems identified were tested, so several show zero cutback to date. All of the data shown is for garnet blasted panels that have the same topcoat within each alloy group. The X-axis shows the alloys tested with and without the CCC. Also note that the Y-axis maximum value is only 7mm.

Looking at figure 1, the largest differences in performance are attributable to the alloy type. The 7075 alloy shows scribe cutback under all CARC variations while the 5086 alloy shows no cutback to date. The CCC did improve performance over the 2024, 6061, and 7075 alloys. The difference in performance between the water-reducible and the solvent-borne primers is marginal at best and tends to favor the water-reducible in this test.

Salt Fog Exposure Testing

No through film corrosion was observed on any of the coating systems. Light density blistering was observed around the intentional scribes of some systems after 1500 hours. Alloys 2024, 6061, and 7075 without CCC showed this blistering. These same alloys with the CCC did not blister. No panels showed any other significant deterioration aside from the scribe cutback results.

Figure 2 shows the scribe cutback data after 2000 hours of salt fog testing. The chart parameters and systems are identical to figure 1 except for the maximum Y-axis value of 14mm. The largest trend in performance is seen with the addition of CCC to the CARC systems. In all cases the cutback was reduced by the use of a CCC. The 7075 alloy is more susceptible to underfilm corrosion than the other alloys tested. Use of the water-reducible primer caused a marginal reduction in overall system performance.

Cyclic Corrosion Testing

Following 20 cycles of testing none of the coating systems showed any visual signs of corrosion, blistering, or cutback from the scribe. At the 40 cycle inspection the coatings were beginning to show underfilm corrosion at the scribes. The results after 74 cycles are presented in figure 3. The failures are limited to cutback at the scribes only. Notice the Y-axis scale extends to 18mm.

Figure 3 shows that 2024 aluminum without the CCC had the largest cutback. The trend of CCC improving cutback resistance is not as clear in this data as from other performance tests. The difference between the primer types is, however, more pronounced based on these results. The water-reducible primer was not as durable as the solvent -borne primer. The corrosion shown for the 5086 aluminum was minimal for all variations of the CARC system.

CONCLUSIONS

The following conclusions were made based on the results of the accelerated performance and marine atmospheric exposure tests to date.

- Negligible differences were observed between the water-reducible and solvent-based primers over the 5086 aluminum alloy or over the 6061 alloy with a chromate conversion coating.
- The water-reducible primer allowed more underfilm corrosion than the solvent-based primer over non-chromate conversion coated 6061 aluminum.

- In the GM 9540P accelerated corrosion test the water-reducible primer allowed more underfilm corrosion than the solvent-based primer over the 2024 alloy.
- In general the 2024 and 7075 alloys were more prone to underfilm corrosion than the 6061 or 5086 alloys. The 5086 was the least corrosion prone of all alloys tested.
- The chromate conversion coating generally aided in the performance of the 2024, 6061, and 7075 alloys. Minimal differences were noticed over the 5086 alloy with the addition of the chromate conversion coating.

Recommendations

The historically used CARC systems have included cleaning, a chromate conversion coating, and solvent based coatings. The results herein demonstrate that satisfactory performance of CARC systems can be obtained over some aluminum alloys with more environmentally acceptable materials. The substitution of chromate conversion coating application with abrasive blasting and alkaline cleaning, and the use of water reducible coating formulations are two examples of this trend. The long-term performance of these alternative CARC systems should be monitored to determine that acceptable vehicle performance is maintained. We suggest that follow-on reports be generated for the samples that will remain under marine atmosphere exposure for several years. This will quantify the performance differences and aide in the CARC system decisions for Army materiel.

Figure 1
6 months Marine Exposure

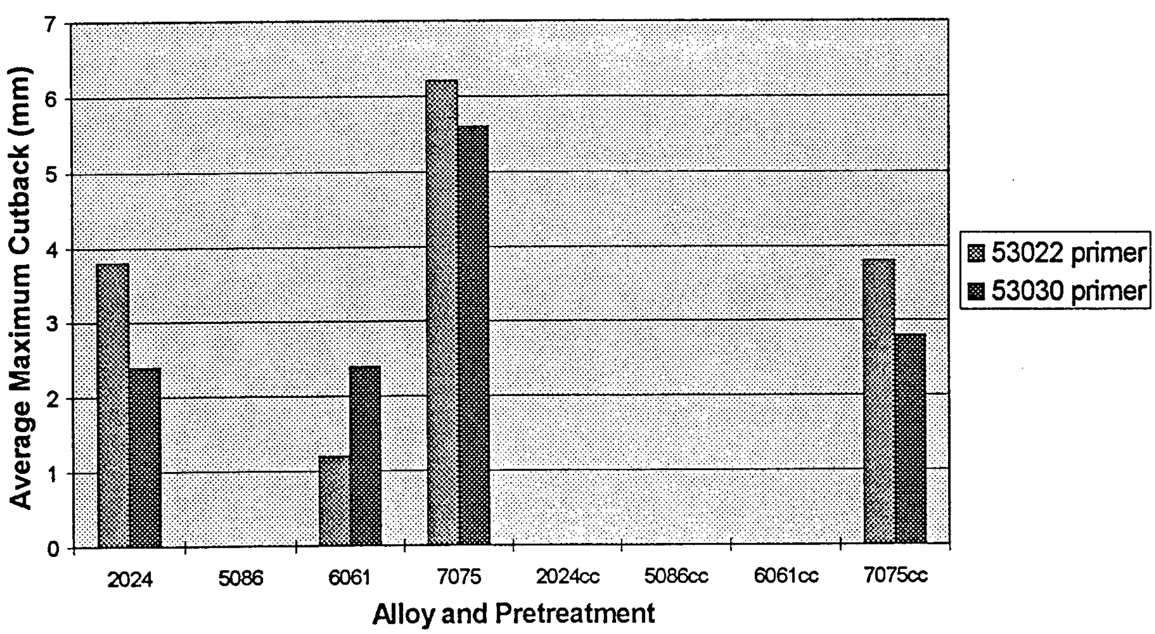


Figure 2
2000 hours salt fog

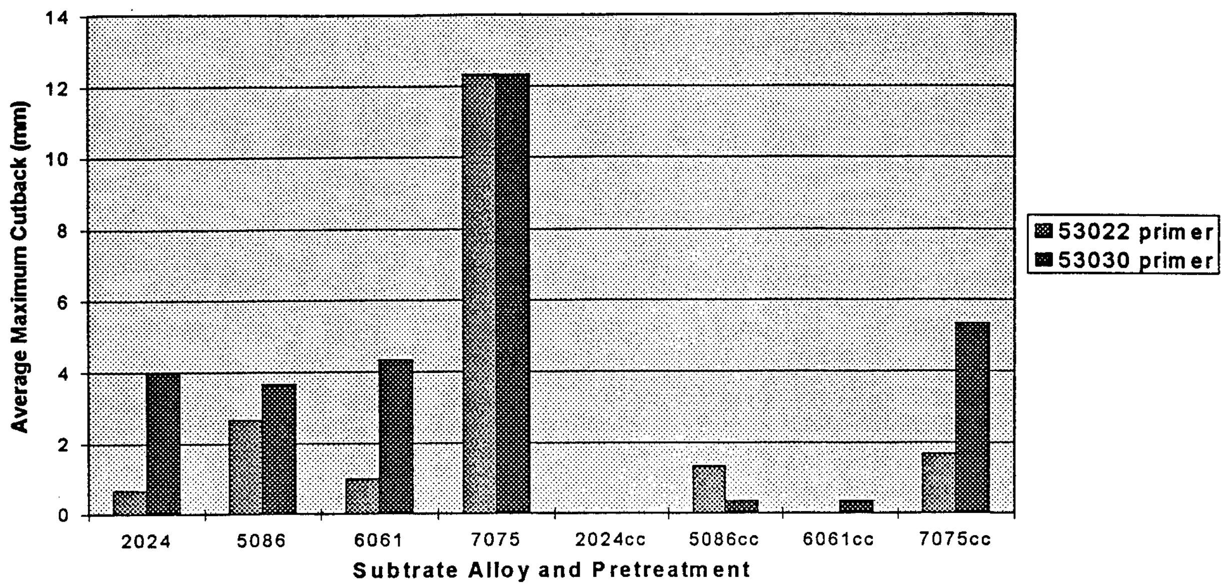
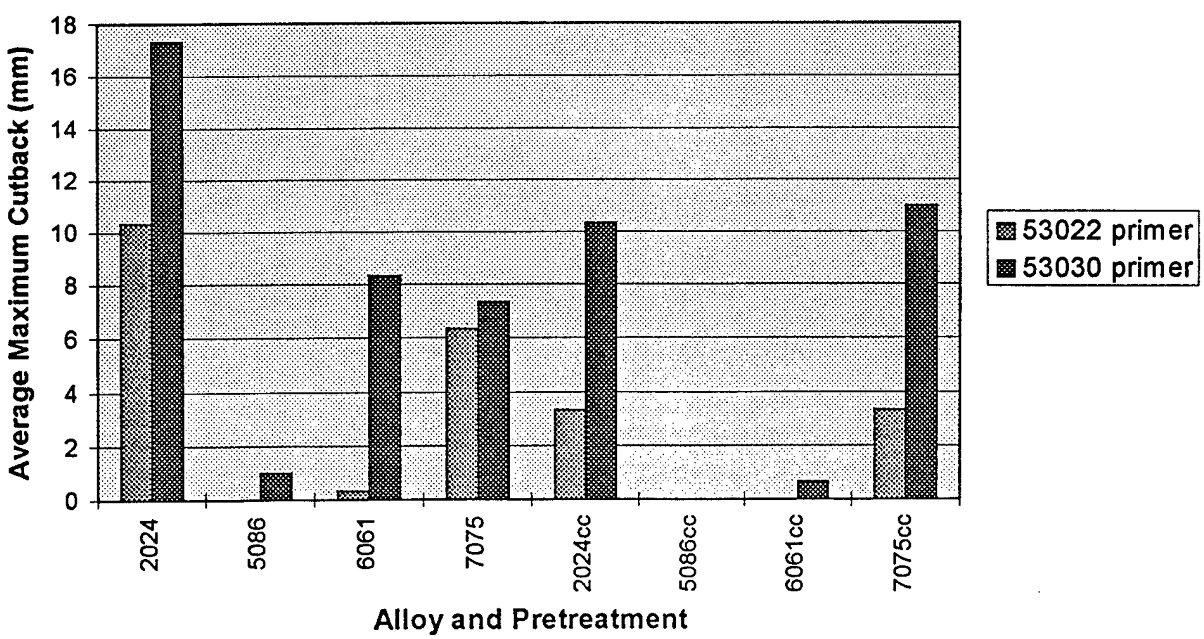


Figure 3
74 cycles GM9540P Cyclic Corrosion Test



Session VII
ODS Management/Reduction

Session Chairpersons:

Ms. Mary Lamb, HQ AFCEE/CCR-S
Mr. Armando De la Paz, Vista Technology

ALTERNATIVE DEGREASING FOR COMPOSITE HONEYCOMB REPAIR

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REGULATORY BACKGROUND

Ozone-Depleting Chemicals

The Montreal Protocol was first implemented in the United States in February 1989 when the EPA issued the final rule "Protection of the Stratospheric Ozone" in the Federal Register (40 CFR Part 82). In 1990, Congress passed the Clean Air Act Amendments. Title VI of these amendments codified the Montreal Protocol production bans and identified 1,1,1 trichloroethane (methyl chloroform, TCA) as a Class I ODC. It also allowed the EPA to further restrict ODC production as the science of ozone depletion developed. In February 1992, President Bush exercised this authority by accelerating the phase-out of Class I ODCs, banning domestic production of halon after January 1, 1994 and all remaining Class I ODCs after January 1, 1996.

In October 1992, Congress enacted unique restrictions on the DoD through the Defense Authorization Act for Fiscal Year 1993 (Public Law 102-484). Section 326 of that law prohibits the DoD from letting contracts that require the use of a Class I ODC. This law predicated the establishment of a detailed contract review process, to be able to identify existing ODC call-outs. Each Service reports approved waivers, initially quarterly and now annually, to Congress.

Toxic Chemicals

In August of 1993, President Clinton signed Executive Order 12856. It's purpose is to "ensure that all federal agencies conduct their facility management and acquisition activities so that, to the maximum extent practicable, the quantity of toxic chemicals entering the wastestream, including any releases to the environment, is reduced as expeditiously as possible through source reduction." Toxic chemicals are identified as "a substance on the list described in section 313(c) of EPCRA." Trichloroethylene (TCE), CAS Number 79-01-6, is identified on this list.

TCE is also one of the 17 high-priority toxic chemicals identified by the EPA's 33/50 Program, with the goal of reducing environmental releases and off-site transfers by 33% in 1992 and 50% in 1995. The Army also identified TCE for special attention when it was reported as one of the top 17 toxic chemicals in the Army's 1995 Toxic Release Inventory (TRI) report.

HONEYCOMB CLEANING

Most work areas at the Corpus Christi Army Depot (CCAD) helicopter maintenance facility have switched from TCA to aqueous-based cleaning systems. These systems are sufficient for cleaning grease and other general contaminants from parts with readily accessible surfaces. Water based cleaning has not proven to be compatible with composite honeycomb parts, however, because they must be completely dry and residue-free before the honeycomb core and skin are adhered. Moisture introduced into the autoclave curing process will expand as it evaporates, which can cause adhesive disbonding, honeycomb damage, or even skin damage.

Portions of damaged helicopter honeycomb skin panels are removed during repair procedures. Replacement portions of aluminum or Nomex honeycomb and skin are then patched into the panels. The aluminum honeycomb is 2024 series aluminum. Composite honeycomb is made of Nomex material. The honeycomb core is typically 0.375 – 0.500 inch thick, with a cell size as small as 0.125 inch and density up to 35 cells per square inch. Floor boards and cargo doors are the must common components processed. These honeycomb panels are typically 20-25 square feet, and can be as large as 75 square feet.

Honeycomb composite repair is classified as either minor or major. A major repair is where the honeycomb core has been significantly damaged and must be replaced. A minor repair is where the damage is only to the skin, or there is a delaminated area where the skin no longer is bonded to the honeycomb core. It is very difficult to affectivity remove all of the contaminants from the tight honeycomb structure below the damage of a minor repair. It is also very difficult to dry the recessed areas of the honeycomb if the cleaning material does not quickly evaporate.

The honeycomb shop had used a small TCA vapor degreaser with a 4 foot x 4 foot x 3 foot tank. At this time, the honeycomb composite repair shop is manually hand-wiping the repair surfaces using Lectra Clean, a TCE product which comes in an aerosol can. When using TCA or TCE, the parts are dry after cleaning. There are therefore no specific process time constraints that dictate how quickly an alternative material needs to evaporate. One of the key concerns expressed by the repair personnel, however, is for the solvent to dry fast and leave no residue. Typical total-repair process time for a large floorboard may take over 70 hours, so any additional time spent waiting for the part to dry (or drying the part) is significant.

No testing is done to verify the cleanliness of the surface in the shop, other than visual inspection. If a part is found to have not been properly cleaned, it is deemed uncleanable and thrown away. CCAD periodically tests the adhesive bond strength of its repaired parts, however, and in this way infers the part's cleanliness before bonding. If a piece fails this test, then a failure analysis is conducted to determine if the failure was due to improper cleaning, bad adhesive, or defective test materials. Tests include T-peel, lap sheer, and climbing drum peel mechanical tests. In the case of vapor degreasers, the solvent reservoirs are monitored on a regular schedule to make sure that the solvent concentrations, temperatures, etc. are within the design parameters.

TECHNICAL APPROACH

The requirements for an alternative cleaning material and/or process were identified as:

a. It remove the same contaminants from the surface to the same level as TCA.
b. It dry quickly without significant residue.
c. It not create the need for a large new piece of equipment.
d. It cause minimal worker health impacts (not carcinogenic, mutagenic, etc.).
e. It has minimal environmental impacts (low VOC, non-ODC, etc.).
f. It have minimal safety impacts (low flammability, low explosion risk, etc.).

The project had two phases: 1) engineering analysis and laboratory evaluation, and 2) demonstration of recommended cleaning system(s) in the composite shop. All the laboratory tests are briefly described in this paper.

Test Materials

The following is are the alternative cleaning agents evaluated under this program.

Triagen – Ecolink, Inc.
An alkyl bromide-based (normal propyl bromide) blend available in aerosol form

Positron – Ecolink, Inc.
A terpene-based (heavy hydrocarbon), high purity dielectric solvent.

Vertrel MCA Plus – Dupont Fluoroproducts
An azeotrope of hydrofluorocarbons with trans-1,2-dichloroethylene and cyclopentane.

Oxsol 100 - Occidental Chemical Corp.
A fluorinated toluene whose chemical name is parachlorobenzotrifluoride.

OS-120 - Dow Corning Corp.
An azeotrope of volatile methyl siloxanes (VMS) developed for precision cleaning.

HFE-7100 - 3M Chemicals
A hydrofluoroether (HFE) compound, specifically methoxynonafluorobutane.

Envirosolve 655 - Fine Organics Corporation
A solvent blend of an isoparaffinic hydrocarbon and a proprietary organic solvent.

SC 431 - Calgon Corp.
A non-chlorinated solvent made from a petroleum distillate blend.

Pure ethyl lactate
An extremely fast evaporating, organic solvent currently used as a food additive.

DS 108 - Dynamold Solvents, Inc.
A precision hand wipe solvent whose principle constituent is ethyl propionate.

HyperSolve-NPB – Great Lakes Chemical Corp.
An n-propyl bromide based chemical blend designed for vapor degreasing.

Partsprep – Ecolink, Inc.
A solvent blend whose principle constituent is n-methyl pyrrolidone (NMP).

Test Methods

First, engineering research was conducted on the candidate solvents to gather technical information in the following four main areas:

1. Physical properties of the cleaner, as related to the cleaning process.
2. Ability of the alternative to clean.
3. Effect of the cleaner on the structural materials of the helicopters.
4. Environmental, worker health and safety issues related to the cleaner/process.

I. *Physical Properties of the Cleaning Material*

Physical properties such as boiling point and flash point were collected for chemicals of each material family. The evaporation rates, deemed critical to the composite shop cleaning process and not listed on all the MSDS, were verified through the following tests.

Evaporation Rate. ASTM D1901, "Relative Evaporation Time of Halogenated Organic Solvents and Their Admixtures." This test involves pouring the solvent over a panel with a scribed edge. The time is recorded when a break in the continuity of the coverage occurs. The time is also recorded when the residue can no longer be detected along the scribe. This test was repeated in triplicate and then compared to the times of the controls (TCA and TCE).

Gravimetric Testing. A known volume of solvent was placed in a pre-weighed aluminum container. The change in weight of the solution was monitored over time, as was temperature and humidity. The mass-loss rate was used to compare the rate for different cleaning materials.

II. Cleaning Ability

Tests conducted to evaluate the cleaning ability of the material were chosen for their relationship to current procedures performed at CCAD, as well as ASTM standard procedures. Cleaning efficiency was measured by taking the amount of soil removed by a cleaner based on gravimetric calculations. Visual examination and physical testing of bonded joints was also done.

Preparation. ASTM G-121, "Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents." Test panels were cleaned with an acetone rinse to prepare uniform surfaces and pre-weighed. They were then rinsed in solutions containing different contaminants. The panels were then dried and weighed.

Cleaning Efficiency. ASTM G-122, "Standard Test Method for Evaluation the Effectiveness of Cleaning Agents." The composition of the contaminant was MIL-L-23699 (50 gm), MIL-H-5606 (50 gm), LIM-H-83282 (50 gm), 2024 aluminum shavings (5 gm), and Nomex and Kevlar "dust" (2.5 gm each). The panels were cleaned in the various test solutions, dried, and re-weighed. The weight of soil remaining on the panel was determined, and the cleaning efficiency was calculated for each test material. Visual examination was also used to identify and examine any residue that remained on the panel surface.

Adhesive Bond Strength. ASTM D1002, "Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal)." This test evaluated the quality of the cleaning process by through the adhesive strength of the subsequent bonded structure. Overlapped panels were bonded after cleaning with the alternate cleaners. The specimens were then placed in a tensile loading machine and a load was applied until failure occurred. The failure loads were recorded and compared to standard values. Bond failures were also analyzed to determine where the failures occurred - at the adhesive bond layer, within the adhesive material, or within the material.

III. Physical Effects of Cleaner on Substrates

It was also important to determine if the alternate cleaners had any affect on the basic mechanical properties of the substrate. Testing was conducted on samples of 2024 aluminum and Nomex/Kevlar composites. Information was also gathered from the failure analysis of the physical testing conducted to evaluate the cleanability of the alternate materials.

Immersion Corrosion. ASTM F483, "Total Immersion Corrosion Test for Aircraft Maintenance Chemicals." Samples of substrate materials were pre-weighed and then immersed at a constant temperature of 38 $\pm$3 °C (100 $\pm$5 °F). The solution volume-to-material area ratio was at least 8 ml/cm^2. After 24 hours of immersion, the samples were dried and weighed again with appearance noted. Then the samples were again immersed for another 144 hours. The weight and visual changes were again recorded. Finally, the weight gain or loss was calculated.

Tests were also performed to evaluate the effects of the cleaners on composites during exposure by measuring the increase in weight of the polymer test samples in relation to the time of immersion. This testing was based on ASTM D5229, "Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials."

Sandwich Corrosion. ASTM F1110, "Sandwich Corrosion Test." Each solution was added to a set of three panels. Each day the panels were placed in the humidity chamber at 95-100% humidity, and 37.7°C (100°F) for 8 hours. Panels were then oven dried at 37.7°C (100°F). After exposure, panels were rinsed and visually inspected for corrosion.

Effects on Unpainted Surfaces. ASTM F-485, "Effects of Cleaners on Unpainted Aircraft Surfaces." Two panels of each substrate were cleaned to ensure clear results. Specimens were immersed for 3-5 minutes in the cleaning solution that covered half the panel, followed by drying for 30 minutes in a convection oven at 150°F (65.5°C). After cooling, the panels were rinsed with tap water for one minute and then distilled water for 15 seconds. The panels were then visually examined by comparing the immersed and untreated parts against one another.

IV. Environmental, Worker Health, and Safety Issues

Information was gathered on environmental, health, and safety issues for each of the alternate materials in addition to test performance data.

CONCLUSIONS

The following conclusions summarize the results from the engineering analysis, phase 1, and phase 2 testing. Details on the results of the testing, as well as the raw test data, are contained in the body and appendices of "Alternative Degreasing for Composite Honeycomb Repair," prepared for the U.S. Army Industrial Operations Command, Corpus Christi Army Depot, dated 31 March 1998.

Conclusion #1: Only two of the candidate solvents satisfied all the key requirements identified: HFE-7100 and Vertrel MCA (Plus). Both cleaned as well and evaporated as fast as TCA and TCE, do not require new equipment, have minimal health impacts (200 and 600 parts per million exposure limits, respectively), are VOC exempt, and are non-flammable. Both are therefore acceptable alternatives.

Conclusion #2: Two other candidates, Triagen/Hypersolve and OS-120, were also considered acceptable alternatives. They cleaned as well and demonstrated evaporation rates on a par with TCA and TCE, do not require new equipment, and have acceptable exposure limits of 200 parts per million. They also both cost considerably less than HFE 7100 and Vertrel MCA (Plus). OS-120, however, is a flammable liquid and requires special storage and handling considerations.

Conclusion #3: There is some concern over the performance of Vertrel MCA (Plus) in the demonstration conducted on the shop floor. Subjective comments were received that it did not adequately clean certain oil and hydraulic fluid from the honeycomb core. This should be further defined and analyzed before the HFC is implemented in the shop.

Conclusion #4: Further testing should be accomplished to identify the performance of these four solvents in other hand-wipe and vapor degreaser applications in CCAD for the potential replacement of other hazardous or toxic solvents.

Conclusion #5: Further testing should be accomplished to pursue the use of pure ethyl lactate. This material is not yet ready for use in a major industrial application, but the small sample that was acquired performed very well in the tests in which it participated. Limited available quantities currently force the price beyond all the other solvents. As more interest is generated, however, more product will be produced and the price should come down to at least that of the HFEs and HFCs.

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Ozone Depleting Chemicals (ODCs) Management and Reduction at U.S. Army and Army Reserve Facilities

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Abstract

Managers and environmental coordinators responsible for implementing Pollution Prevention (P^2) initiatives, should be aware of global, federal (EPA), Army and Army Reserve regulations for ODCs. This paper identifies what is involved in the planning process of ODC elimination, and how to succeed in reducing current ODCs and ultimately eliminate them.

Ozone Science

The Earth's atmosphere is divided in several layers or regions. The lowest region, which extends from the Earth's surface up to about 10 kilometers (km) in altitude, is called the troposphere. Most human activities occur in this sphere. The next layer, the stratosphere, continues from 10 km to about 50 km. Most commercial airline traffic occurs in the lower part of the stratosphere. Atmospheric ozone is concentrated in the stratosphere, about 15 to 30 km above the Earth's surface. Ozone is a molecule containing three oxygen atoms, is blue in color and has a strong odor compared with normal oxygen, which has two atoms, is colorless and odorless.

Ozone plays a key role in the atmosphere. This ozone layer in the stratosphere absorbs about 95% of the radiation from the sun, (ultraviolet light called UVB) preventing it from reaching the planet's surface. Increased UV radiation in the troposphere, can result in increased amounts of photochemical smog and can contribute to global warming. UVB has been linked to many harmful effects, including various types of breathing problems, skin cancer, cataracts, is harmful to some crops, certain materials (e.g. plastics), and some forms of marine life.

An example of a reaction that occurs under incident UVB radiation is as follows:
$Cl + O_3 = ClO + O_2$
$ClO + O = Cl + O_2$, yielding $O_3 + O = 2O_2$ (Chlorine atoms are the catalysts in this reaction.)

At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount remains relatively stable. Although ozone concentrations vary with naturally occurring sunspots, seasons, and latitude, these processes are understood and predicted by scientists. Scientific records have been established spanning several decades that detail normal ozone levels during these cycles. Each natural reduction in ozone levels has been followed by a recovery. However, in the last years, more convincing scientific evidence has shown that the ozone shield is being depleted well beyond changes due to natural processes. These changes have been attributed to manmade processes and chemicals, specifically to emission of a particular group of industrial chemicals called halogenated compounds. These halogenated compounds include common chlorofluorocarbon (CFC) groups, halon groups, methyl chloroform, carbon tetrachloride and hydrochlorofluorocarbons (HCFCs). These compounds have been classified based on their "ozone-depletion potential" (ODP), which indicates the ability of a chemical to destroy stratospheric ozone.

Ozone Regulations

42 U.S.C., Section 7671a(a) or Appendix A, 40 CFR Part 82, Subpart A, Title VI, Section 602 of the CAA, as amended in 1990, establishes two main classes of ODCs, Class I and Class II, which consist of individual groups of chemicals. The Class I chemicals are the most potent ozone depleters (often containing a bromine-an effective catalyst in ozone depletion) and Class II chemicals include other less potent ozone depleters. In an attempt to reduce the effect of ODCs on the environment, more than 125 nations (including the United States) signed an international agreement known as the Montreal Protocol to limit ODC production. In 1990, the Montreal Protocol, as well as the Clean Air Act were amended to mandate the eventual elimination of the manufacture and use of most ODCs. The CAA Title VI provides stricter controls on ODCs than the Montreal Protocol, but adheres to a similar phaseout schedule. The CAA also requires HCFC production to be phased out by the year 2015, five years ahead of the Montreal Protocol schedule.

The U.S. Congress took independent initiative to emphasize the need for the defense agencies and military departments to reduce requirements that lead to the use of ODC's. The National Defense Authorization Act for Fiscal Year 1993, Public Law 102-484, includes legislation addressing ODCs in Section 325 and 326. Section 325 titled "Evaluation of Use of Ozone-Depleting Substances by the Department of Defense," places a requirement on the Director of the Defense Logistic Agency (DLA) to evaluate the use of Class I and Class II ODCs by the military departments and defense agencies and report the results of the evaluation to Congress. Section 326 titled "Elimination of Use of Class I, Ozone-Depleting Substances in Certain Military Procurement Contracts," directs the DoD to put in place procedures to evaluate contractual requirements that lead to the use of Class I ODCs. In recognition of the above mandate, the US Army implemented the guidance of DoD Directive 6050.9 (1989) and the Montreal Protocol by issuing Headquarters, Department of the Army letter (HQDA LTR) 200-90-1, "Elimination or Minimizing Atmospheric Emissions of Ozone-Depleting Substances." This letter provided important direction toward eliminating the use of halons and CFCs for both tactical and nontactical applications, and authorized the formation of a General Officer Steering Committee (GOSC). HQDA 200-92-1 was incorporated into AR 200-1 and DA Pamphlet 200-1.

In 1992 and 1994, both the Assistant Secretary of the Army for Research, Development, and Acquisition (SARDA) and the Deputy Assistant Secretary of the Army for the Environment, Safety, and Occupational Health within the Office of Assistant Secretary of the Army for Installations, Logistics, and Engineering (SAILE), authorized the Army Acquisition Pollution Prevention Support Office (AAPPSO), as the designated lead office for all Pollution Prevention (P^2) initiatives, and managing the Army ODC Elimination Program for the Department of the Army.

Subsequently, Executive Order 12843 signed in 1993 established a national policy and formal requirements for the Federal government to implement cost-effective programs to minimize the procurement of materials and substances that contribute to the depletion of the stratospheric ozone; and to give preference to the procurement of alternative chemicals, products, and

manufacturing processes that reduce overall risks to human health and the environment by lessening the depletion of ozone in the upper atmosphere.

Finally, the Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health) issued policy memo 1994 entitled "Disposition of Excess Ozone-Depleting Substances at Army Installations." This policy expanded the DoD policy to turn in ODCs and included a definition of the term "excess."

ODC P² Army Goals

In response to the regulatory controls on ozone-depleting substances, the Army has established P² goals for the reduction and eventual elimination of ODCs in fire suppression equipment and systems, automotive vehicle degreasing and cleaning compounds, vehicle air conditioners, and facility air conditioning and refrigeration units which are sources of Class I and some Class II ODCs. The 1995 *"Strategic Guidance and Planning for Eliminating Ozone-Depleting chemicals from U.S. Army Applications,"* sets forth guidance and objectives for ODC elimination for facilities as summarized below:

- The Army would manage the ODC elimination policy and program centrally through the Army Acquisition Pollution Prevention Support Office (AAPPSO); and that execution of this strategy would be through the Major Command (MACOM) commanders and installations.

- The Army would rely on industry to the maximum extent possible for alternatives and technical solutions for ODC applications and phase-out.

- Each use of ODCs would a) be eliminated, or b) replaced with an environmentally safe alternative, approved by U.S. EPA's SNAP (Significant New Alternatives Policy), under the Clean Air Act, Title VI, Section 612.

- ODC retrofit or replacement of existing hardware would be required.

- Existing quantities of ODCs would be conserved and reused to the maximum extent possible and an ODC Reserve be setup for that specific purpose.

- All new chemicals introduced must receive a toxicity clearance from the Surgeon General before use.

Also according to Army Reserve guidelines established in line with Army Directives in the *"United States Army Reserve Command Pollution Prevention Plan, July 1997,"* Regional Support Commands (RSCs) should insure that facilities with significant ODC equipment and processes develop an ODC Elimination Plan. The following is the suggested content of the RSC ODC Plan:

- Actively practice ODC recycling where appropriate by purchasing ODC recycling equipment

- Establish preventative disposal procedures by removing refrigerants prior to scrapping
- Maximize refrigerant recycling by cascading refrigerants captured during equipment repair or scrapping
- For equipment that contains in excess of 50 pounds of refrigerant, maintain service records for refrigerants added to equipment and repair substantial leaks
- Assure personnel servicing equipment are Section 608 certified.

In most cases, ODC-containing equipment should be replaced through attrition. Factors to be considered in the life cycle analysis of equipment include cost of replacement or conversion, energy costs, and operation and maintenance costs. Mission-critical equipment such as weapon systems are to be retrofitted in stages by the DA and funded through alternative funding channels. Small appliances (containing less than 5 pounds ODC) are typically hermetically sealed, and therefore, difficult to retrofit with an alternative coolant. For this equipment, the Army and Army Reserve recommends that maintenance be performed by individuals certified under Section 608 of the Clean Air Act and that ODCs be reclaimed prior to scrapping the equipment. Chillers and air conditioners, on the other hand, typically are more easily retrofitted with an approved (SNAP) ODC substitute. As a rule-of-thumb, the Army and Army Reserve recommends that chillers older than fifteen years be replaced, and chillers less than five years be retrofitted. It is also recommended that refrigerant conversion be performed by the chiller manufacturer or by a contractor who represents the manufacturer.

ODC Elimination Plan

The Army Material Command has developed a generic ODC elimination plan for all Army facilities to use as guidance for developing their own specific facility plan. This plan provides a prioritization system for replacement or retrofits of equipment. Specific equipment types targeted for ODC elimination are Halon 1301 fire suppression systems and Halon 1211 fire extinguishers. When replacing a fire extinguishing system, the fire risk is first examined to determine if the fire suppression system is sufficient. Insufficient fire suppression systems and systems requiring frequent maintenance are given top priority for equipment retrofit and replacement. Low priority systems retrofit or replacement factors include recent installations, low maintenance, CFC-13 refrigerant (an alternative currently available), and sealed systems. All retrofit and replacement decisions are to be consistent with sound business practices, and make good economic sense. Those systems that have sufficient fire suppression are then prioritized based on the ease in which the system can be converted to a non-ODC system.

Guidance is also provided for eliminating CFC used in facility air conditioning and refrigeration applications. Once this equipment has been inventoried and prioritized for replacement or retrofit, primary emphasis is then placed on large air conditioning/refrigeration systems with capacities greater than 100 tons. Secondary emphasis is placed on smaller air conditioning and refrigeration units. The hierarchy for equipment replacement takes into account the 1) operating

condition of the equipment, 2) alternative refrigerant chemicals available, 3) lubricant replacement, 4) additional parts required for retrofit, and 5) mechanical room safety modifications recommended by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). Each ODC application is reviewed individually to determine the easiest and most cost-effective method for eliminating ODC usage.

ODCs Army and Army Reserve Uses

The Army uses CFCs in systems for three engineering purposes: a) component cleaning, b) system cooling, and c) environmental control. System cooling and environmental control unit (ECU) applications include tactical refrigeration and chillers typically used in food service, photographic laboratories, medical, research and other laboratories, tactical shelter air conditioners, vehicle air conditioners; and, fire suppression equipment and systems.

The ODC refrigerants used to cool buildings, motor vehicles, food storage areas, ice machines, and water coolers may include R-12 (Dichlorodifluoromethane [CCl_2F_2]), R-22 (Monochlorodifluoro-methane [$CHClF_2$]), or R-502 (which is a combination of R-22 and R-115). The CFC Halon is widely used as a fire suppression agent, especially in facilities containing electronic equipment that would be damaged by water or other fire extinguishing agents. The typically used halon compounds include those in portable fire extinguishers (Halon 1211 [CF_2BrCl]), and those in fixed fire suppression systems and fire extinguishers (Halon 1301 [$CBrF_3$]).

P² Army Minimization Options for ODCs

The following are provided as minimization options for ODCs, They include:

- **Reduce** sources by Retiring Equipment based on need.
- **Retrofit** equipment with an EPA SNAP substitute based on need.
- **Replace** equipment with new EPA SNAP substitute based on need.

Both air conditioning and refrigeration operate on the principle of vapor compression to achieve cooling. This process has long relied on CFCs and HCFCs as the refrigerants of choice in the vapor compression process. The discovery of their probable effect on the ozone layer has resulted in the development of alternative processes, as well as development of new refrigerants.

The first substitute refrigerants developed for CFCs and HCFCs are known as hydrofluorocarbons (HFCs). Since they do not contain any chlorine atoms, HFCs are used, but have some drawbacks, such as higher equipment costs and lower efficiencies than CFC- or HCFC-based systems. In addition, HFCs contribute to global warming when vented. Some main factors to weigh when considering conversion to a substitute halon alternative are as follows:

- Is the candidate substitute been EPA SNAP approved?

- Has the candidate substitute been tested by a nationally recognized testing organization such as Underwriters Laboratories (UL) or Factory Mutual (FM)?

- Does the candidate substitute conform with the National Fire Protection Association Standard for Clean Agent Extinguishing System (NFPA Standard 2001)?

- Does the candidate substitute have zero ozone depletion potential and low global warming potential? If not, it may also be targeted for replacement sometime in the future, e.g., HCFCs.

- Are there non-halocarbon alternatives that would work for the application? If not, what are the halocarbon alternatives?

- Is the existing equipment compatible with the candidate substitute? If not, what are the performance compromises, costs, and retrofit requirements?

The EPA recommends the following strategy for developing effective waste minimization options for ODC reduction and phase-out by years:

- Procedural modification, e.g., modify normal Standard Operating Procedures (SOPs) for reduction and elimination
- Process modification, e.g., reduce, reuse, recycle as P^2 alternative
- Material substitution.

The general Army guidance for P^2 ODC elimination requires several sequential steps of implementation. These steps are outlined below:

- **Inventory of all CFC- and HCFC-based sources and chemicals available to replenish those systems**--i.e. 1) Location of the Equipment, 2) Ownership, 3) Equipment Type and Model, 4) Chemical Used (type, storage, allocation, amount), 5) Operating Record, 6) Maintenance Record, and 7) Future Plans.

- **Apply Conservation Measures** by establishing a strong maintenance plan aimed at conserving and recovering CFC chemicals.

- **The installation should reuse the refrigerant** from these systems as they are replaced or retrofitted to maintain the remaining air conditioners and refrigerators. The recovered refrigerants can be utilized throughout the elimination program as long as it is used in facility equipment on the installation.

- **Building a management plan to eliminate ODCs and establish priorities** such as personnel required to maintain equipment, repair, recover CFCs and retrofit equipment.

ODC Milestone Deadlines

The following table contains milestones and deadlines for ODC elimination.

Pollution Prevention ODC Milestone Deadlines

Type of ODCs	ODCs	PRODUCTION PHASE-OUT MILESTONES		RETROFIT & REPLACEMENT PHASE-OUT
	100% Production Phaseout	**Milestone[1]**	**Milestone[2]**	**Milestone[3,4]**
Class I	Halon 1211, 1301, and 2402	1 January 1994	1 January 1994	
Class I	Chlorofluorocarbons (CFC) 11, 12, 13, 111, 112, 113, 114, 115, 211, 212, 213, 214, 215, 216, 217, 500, 502	1 January 1996	31 December 1995	*Before 1 January 2000
Class I	Carbon Tetrachloride	1 January 1996	31 December 1995	
Class I	1,1,1-Trichloroethane (Methyl Chloroform)	1 January 1996	31 December 1995	
Class I	Hydrobromofluorocarbons (HBFC)	1 January 1996	1 January 1996	
Class I	Methyl Bromide		1 January 2001	
Class II	HCFC-141b		1 January 2003	Before 1 January 2003
Class II	HCFC-142-b		1 January 2010	Before 1 January 2020
Class II	HCFC-22		1 January 2010	Before 1 January 2020
Class II	Other HCFCs	1 January 2030	1 January 2015	Before 1 January 2030

***Except refrigeration and air conditioning equipment - Before 1 January 2003.**

1 Copenhagen and London Amendments to the Montreal Protocol.
2 U.S. EPA Clean Air Act (42 U.S.C. 767a(a)), 40 CFR Part 82, Section 604.
3 Strategic Guidance and Planning for Eliminating Ozone-Depleting Chemicals from U.S. Army Applications.
4 "The Accelerated Phaseout of Ozone-Depleting Substances," Stratospheric Ozone Protection-Final Rule Summary, U.S. EPA, Washington, D.D., EPA 430-F-93-057, December 1993.

Conclusion

Building a management plan and establishing priorities for elimination of ODCs is a priority for each facility or installation. This plan needs to be part of the P^2 initiatives of the facility. With deadlines fast approaching (retrofit and replacement phase-out of Class I ODC before January 1, 2000), it is recommended that managers establish a plan and allocate the necessary funding now for ODC elimination.

SESSION VIII
P² IN MUNITIONS

SESSION CHAIRPERSONS:

Lt Colonel Brian McCarty, HSC/XRE
Mr. Christopher Miller, Montgomery Watson

Session IX
P^2 Through Energy Efficiency

Session Chairpersons:

Mr. Richard Freeman, HQ AETC/LG-EM
Mr. Rick Galloway, Radian International

Fuel Cells: Meeting the DOD's Critical Energy Requirements

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INTRODUCTION

The use of fuel cells in Department of Defense (DOD) applications was investigated with an emphasis on stationary power applications, as opposed to transportation and portable power applications. In addition to investigating the current uses of fuel cells, several DOD-unique applications for the "premium power" offered by fuel cells were identified. Fuel cell operating and economic data were collected for analysis and air pollution emission reductions were quantified. Collectively, this information is useful for DOD decision makers in evaluating potential sites for future fuel cell installations.

BACKGROUND

A fuel cell is an electrochemical device that converts chemical energy into usable electricity and heat without combustion as an intermediate step. A fuel cell power plant is composed of four major subsystems: the fuel processor or reformer, the power section, the power conditioner, and the thermal energy recovery system. The fuel processor or reformer converts a hydrocarbon fuel, typically natural gas, into a clean, hydrogen-rich gas. The power section is where the hydrogen-rich gas combines with oxygen to produce direct current (DC) power, heat, and water. The power conditioner converts the DC power into clean, alternating current (AC) power. A thermal energy recovery system removes the fuel cell by-product heat and diverts it to a heat exchanger for use in thermal applications.

Fuel cell technology offers several environmental and operational advantages over conventional fossil fuel power generation methods. Fuel cell exhaust emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), and other pollutants are well below even the most stringent regulatory levels. In addition to low pollutant emissions, fuel cells also operate at low noise levels (below 60 decibels). This allows installation in and adjacent to buildings and makes fuel cells an attractive option for energy generation in urban areas. Finally, fuel cells can operate on a wide variety of fuels, including natural gas, petroleum products, ethanol, methanol, coal-derived gas, landfill gases, and biogas.

Four types of fuel cells are currently under development: phosphoric acid fuel cells (PAFCs), polymer electrolyte membrane fuel cells (PEMFCs) (also known as proton exchange membrane fuel cells), molten carbonate fuel cells (MCFCs), and solid oxide fuel cells (SOFCs). Low-temperature fuel cell technologies (PAFC and PEMFC) are well suited for transportation and

light-duty cogeneration applications. High-temperature technologies (MCFC and SOFC) are suited for larger multi-megawatt applications having high-duty cycles.

Although several fuel cell technologies are being researched, developed, and demonstrated around the world, ONSI (a subsidiary of International Fuel Cells) currently offers the only commercially available fuel cell in the U.S. It is a 200-kW PAFC system with the current version marketed as the model PC25™C. ONSI has sold more than 100 stationary fuel cells worldwide and has proven the effectiveness and efficiency of this technology in a variety of applications.

The PC25™C is designed for automatic, unattended operation. The power plant can power electrical loads either in parallel with the local utility grid or isolated from the grid. With an electrical output of 200 kW, the PC25™C has an electrical efficiency exceeding 40 percent (lower heating value) and an overall efficiency approaching 85 percent if the waste heat is recovered. The PC25™C provides over 700,000 Btu/hr of useful heat at temperatures in the range of 140°F. A high-grade heat recovery option is available to provide more than 300,000 Btu/hr at 250°F.

DOD FUEL CELL APPLICATIONS

The DOD is the single largest user of energy in the world. Due to their high efficiency, the use of fuel cells has the potential to reduce the DOD's fossil fuel consumption by 20 percent by the year 2005. In addition, fuel cells will also aid the DOD in achieving environmental compliance and meeting pollution prevention goals by significantly reducing air emissions.

The National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (*CTC*), has been tasked to support the Environmental Security Technology Certification Program (ESTCP) in investigating the use of fuel cells in DOD applications. To date, 30 fuel cells have been installed at DOD facilities. Most of these installations are for non-critical electric and heating applications. However, depending on their configuration, fuel cells can also provide "premium power" to critical or semicritical loads that require higher quality and/or reliability than that normally provided by the electric utility grid. For example, fuel cells can be used to provide continuous power while serving as a backup or uninterrupted power supply. Fuel cells can also provide power to remote sites that are not connected to a utility power grid. For future fuel cell installations, the DOD should take greater advantage of the premium power offered by fuel cells.

Ten high-impact, premium power applications have been identified for the DOD, including:

- Medical Treatment Facilities
- High-Security Facilities
- Communications and Data Centers
- Advanced Manufacturing Processes
- Electronics Manufacturing Processes
- Air Traffic Control Facilities
- Radar Sites
- Shipboard Service
- Research and Testing Facilities
- Remote Sites and Field Operations

In addition to these premium power applications for AC power, several potential DOD applications have been identified for the DC power generated by fuel cells. These applications include many electrotechnologies, such as electroplating, electrocoating, and other industrial processes found in many Army, Navy, Air Force, and Marine Corps maintenance and repair facilities.

Finally, potential alternative fuel sources that can be used to power a fuel cell have been identified. DOD facilities with sewage treatment plants and landfills can use the hydrogen-rich biogas recovered from these sources to generate electricity using fuel cell technology. Other means of generating a hydrogen-rich gas, such as industrial heat treatment processes could also be utilized.

While the focus of this study is on applications for fuel cell power, several thermal applications for the recovered heat are also available. In many applications, the thermal energy is used to heat water for space heating, domestic use, or even recreational use (e.g., swimming pools). Using the high-grade heat recovery option, it is also feasible to use the waste heat from a fuel cell to run an adsorption chiller or provide desiccant regeneration for humidity reduction systems. In applications in which the waste heat is not used, it is removed from the fuel cell via a separate cooling module.

DOD CLIMATE CHANGE FUEL CELL PROGRAM

The fuel cell program within the DOD has different features and criteria depending on the funding for a particular fiscal year. In the past, some sites received total funding for equipment and installation, while others received a portion of the total cost. Also, the agency that is responsible for administering the program varies from year to year. Specific details for the different fiscal years, past and present, are provided in Table 1.

Table 1. Past and Present Fuel Cell Program Characteristics

Fiscal Year	Program Management	Available Funding	No. of Fuel Cell Installations
1993/1994	USACERL[1]	$18,000,000 (FY93) $18,750,000 (FY94)	12 (FY93) 18 (FY94)
1995	DOE[2]	$8,200,000 (up to $1000/kW)	3 DOD 21 non-DOD 9 non-DOD foreign
1996/1997	DUSD-ES[3] (TACOM-ARDEC[4])	$10,400,000 (up to $1000/kW)	53 grants awarded
1998	DOE[2]	~ $5,000,000	TBD

1) U.S. Army Construction Engineering Research Laboratories
2) U.S. Department of Energy
3) Office of the Deputy Under Secretary of Defense for Environmental Security
4) Tank-Automotive and Armaments Command, Armament Research, Development, and Engineering Center

The current DOD Climate Change Fuel Cell Program objectives are to reduce greenhouse gas emissions through efficient use of fossil fuels, accelerate fuel cell commercialization for U.S.

manufacturers, and satisfy DOD goals for the environment, mission-readiness, and economy through activities that would stimulate end user applications. The current maximum amount of each grant is $1000/kW or one-third of the project cost, whichever is lower. DOD applicants are given preference over non-DOD sites. However, DOD installations must partner with a private entity, such as an energy services company, who will bear the remainder of the system costs. This last requirement supports the Defense Reform Initiative (DRI), which involves the privatization of utility systems infrastructure.

ECONOMIC ANALYSIS

The decision to purchase a fuel cell is based, in part, upon an economic analysis of a DOD facility's existing energy costs and the anticipated savings from operating a fuel cell. When evaluating fuel cell economics, one must consider the capital costs, operating and maintenance costs, and potential avoided costs from installing a reliable, on-site power plant. Compared to conventional on-site power generation and backup systems, such as diesel generators and battery systems, fuel cells typically have higher capital costs, but can have significantly lower operating and maintenance costs. In many applications, fuel cells are easier to install because of fewer permitting restrictions due to their low levels of noise, vibration, and emissions. In addition, generators and uninterruptible power supply systems only operate during a grid outage. A fuel cell power plant, however, is continuously available, producing power and thermal energy with significant cost savings.

A 20-year life-cycle cost (LCC) analysis of fuel cell technology was conducted to provide DOD decision makers with a reasonable estimate of the costs (and savings) involved with a fuel cell power plant installation. This analysis was calculated for various fuel cell power plant configurations (on-site, backup, uninterrupted, and remote power) using different combinations of natural gas and electric rates (or diesel rates for the remote power configuration) The results of the LCC analysis indicate that for all configurations, the use of a fuel cell results in a net savings in areas with high electric rates (>5.6 ¢/kWh). Even with a low electric rate (<5.6 ¢/kWh) and a low gas rate (<3.29 $/1000 ft^3) the uninterruptible fuel cell configuration results in a net savings.

Power quality problems lead to an increase in the overall cost of electric service, which is not always evident in the energy bills received from gas and electric utility. The impact of poor power quality varies depending on the application. Power outages, distortion, voltage spikes, and sags may result in a loss of data, product damage or loss, equipment damage, loss of productivity (downtime), and increased health and safety risks. These potentially avoided costs are typically difficult to quantify, but should be recognized when doing a complete economic analysis of a fuel cell installation.

In mission-critical applications, direct economic factors may have no bearing on the decision to pursue fuel cell technology. In these applications, the indirect benefits, such as higher quality, increased reliability, and reduced noise and emissions override all other considerations.

AIR EMISSION REDUCTIONS

As a non-combustion energy source, fuel cells reduce the amount of air pollutants attributed to electricity generation. Although the actual quantity and types of pollutants released depend largely on the type of fuel used – pure hydrogen fuel cells, for example, produce zero pollutants – fuel cells consistently emit pollutants at well below the levels emitted by conventional electricity generation technologies.

Emission savings for a natural gas supplied, 200-kW phosphoric acid fuel cell compared to average combustion source generation is provided in Table 2.

Table 2. Fuel Cell Emission Savings

Contaminant	Combustion Source[3] lb/yr	PC25™C Fuel Cell[4] lb/yr	Fuel Cell Emission Savings lb/yr
NO_X[1]	10,174.56	27.00	10,147.56
CO[1]	381.97	38.00	343.97
VOC[1]	57.13	7.00	50.13
SO_X[1]	19,609.67	0.00	19,609.67
PM10[1]	421.15	0.00	421.15
CO_2[2]	3,211,964.63	1,864,500.00	1,347,464.63

1) 1995 Statistical Abstracts of the United States
2) Energy Information Administration, Electric Power Annual Volume II, 1995
3) Source emissions at annual rate of 200kW, 1650 MWh/year, 94% availability
4) IFC documented test and evaluations

NO_x, SO_x, and CO_2 emission reductions equate to an emission savings of 5 tons, 10 tons, and 675 tons per year respectively.

The fuel cell thermal output may also have an effect on emission reductions. This will be the case if the thermal energy is used to offset the thermal energy produced by a combustion source or other electric source. One example of this is the replacement of an existing combustion boiler with the thermal output of a fuel cell. Maximum fuel cell emission savings are realized when electrical and heat outputs are both fully utilized to displace combustion power and heat sources. These savings can accumulate up to 10 tons of NO_x, 20 tons of SO_x, and over 1,000 tons of CO_2 emissions per year relative to combustion electric sources and coal fired thermal production.

These air emission reduction credits may be traded as a commodity on an open market in some states. Air emission trading is an innovative regulatory compliance concept. It is based on the notion that the most cost effective way to improve overall air quality is to create a mechanism that provides incentive for polluters to take advantage of the least expensive pollution reduction opportunities before embarking on more costly reduction options. Emission trading allows those who can cheaply reduce emissions to sell excess allowances to those that would find it difficult to achieve reductions. Thus, a certain level of pollution reductions can be achieved at less cost than if all sources had to make similar reductions.

NO_x and SO_x receive creditable, significant emission reductions if local emission reduction credit programs are available. These Discrete Emission Reductions (DER) or Emission Reduction Credits (ERC) and allowances will yield continuous environmental improvement and are being traded today in several areas. The typical value of common market NO_x credits is $1,000 to $2,000 per ton. SO_x allowances are presently traded at approximately $100 per ton.

Unfortunately, the economics of emission savings from a fuel cell is not as straight forward as is the energy savings. The emission programs throughout the U.S. have varying financial incentives on the saved emissions resulting from fuel cell use. Some state emission programs such as New Jersey, Michigan, and California are beginning to recognize the quantifiable, real emission savings achieved by using fuel cells. This emission savings is then projected to an emission trading program where financial credits may be obtained.

SUMMARY

Fuel cells offer premium power in high-impact applications and can successfully meet the high standards and critical power requirements of the DOD. In addition, fuel cells may play an important role in reducing air emissions from stationary power generation and thermal energy sources. Thus, the installation of fuel cells will assist DOD facilities in complying with Clean Air Act requirements while supporting DOD pollution prevention initiatives. Successful implementation of fuel cells in DOD applications will, in turn, further the development of this technology. This will result in reduced DOD energy costs and improved life-cycle cost savings.

For additional information, please visit our Web site at http://www.ndcee.ctc.com/pdfindex.htm.

Session X
Alternative Fueled Vechicle Workshop

Session Chairpersons:

Mr. Bill Kivela, HQ AFCEE/EQP
Mr. Phil Mock, SA-ALC/EM

Session XI
Installation Application of P²

Session Chairpersons:

Mr. Richard Eichholtz, Army Environmental Center
Mr. John Gillis, Earth Technology

Pollution Prevention Opportunity Assessment
for Targeted EPA-17 Toxic Chemicals and Hazardous Waste Streams

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Under contract to Headquarters, Air Force Center for Environmental Excellence (HQ AFCEE), Earth Tech, Inc. (Earth Tech), has prepared this Opportunity Assessment (OA) to develop a detailed report that assesses the status of actions that have been, will be, or could be implemented at Pacific Air Force (PACAF) installations to further reduce or eliminate the use of hazardous materials and the generation of hazardous waste. This effort was accomplished through suggested chemical and process substitutions, minimization of hazardous chemicals or processes, reuse or recycling, or a combination thereof. The OA focused on identifying and validating environmentally friendly alternatives for targeted processes that use the greatest amount of U.S. Environmental Protection Agency (EPA) Industrial Toxic Pollutants (ITP), also known as EPA-17 toxic chemicals, and contribute the most to the generation of hazardous waste. Table 1 lists the EPA-17 toxic chemicals.

Table 1. EPA-17 Toxic Chemicals

Organic Toxic Chemicals	Chemical Abstract No.
Benzene	71-43-2
Toluene	108-88-3
Xylene	1330-20-7
Carbon Tetrachloride	56-23-5
Chloroform	67-66-3
Dichloromethane	75-09-2
1,1,1 Trichloroethane	71-55-6
Trichloroethylene	7-01-6
Perchloroethylene	127-18-4
Methyl Ethyl Ketone (MEK)	78-93-3
Methyl Isobutyl Ketone	108-10-1
Inorganic Toxic Chemicals	
Cadmium and compounds	7440-43-9
Chromium and compounds	7440-47-3
Cyanides	varies
Lead and compounds	7439-92-1
Mercury and compounds	7439-97-6
Nickel and compounds	7440-02-0

The OA provides the PACAF installations with a tool to support compliance through pollution prevention (P2), and to provide a mechanism for cross feeding information among the PACAF installations. Effective implementation of P2 opportunities requires coordination and focused efforts on the part of all Air Force personnel involved in handling or generating hazardous materials/waste.

The processes in which EPA-17 chemicals are used, and hazardous waste streams selected for evaluation in the OA, include:

EPA-17 Chemical Processes
- Aircraft painting
- Aerospace Ground Equipment (AGE) painting
- Solid film lubricant
- Methyl Ethyl Ketone (MEK) as a wipe solvent
- Aerosol paint alternatives
- Cleaner, lubricant, and preservatives
- Corrosion preventative compounds
- Miscellaneous hazardous materials alternatives.

Hazardous Waste Streams
- Absorbents
- Paint wastes
- Naphtha/PD-680
- Blasting media
- Jet washer rinseate
- Excess hazardous materials
- Paint filters
- Rags containing MEK
- Batteries.

Prior to identifying options and alternatives, the root cause for each EPA-17 process or hazardous waste stream was identified. Once the root cause was identified, alternatives were developed to eliminate or reduce the source. Options and alternatives were first screened to determine whether there is justification for carrying them forward for further evaluation. Those that survived the screening process were evaluated for technical and economic feasibility, and for their impact on the baseline for hazardous materials use and disposal. The options and alternatives considered the EPA P2 hierarchy (reduce, reuse, recycle) and source reduction techniques, including:

- Substitution
- Product reformulation
- Process change or modification
- Process upgrade/update
- Improved operation and maintenance
- Recycling.

This study was conducted during the summer of 1997. In some instances, the evaluation was inconclusive because an acceptable substitute could not be identified, or the potential use could not be confirmed. Additional information may now be available to confirm a product or verify its non-applicability. A flow diagram for identifying alternative products is presented in Figure 1.

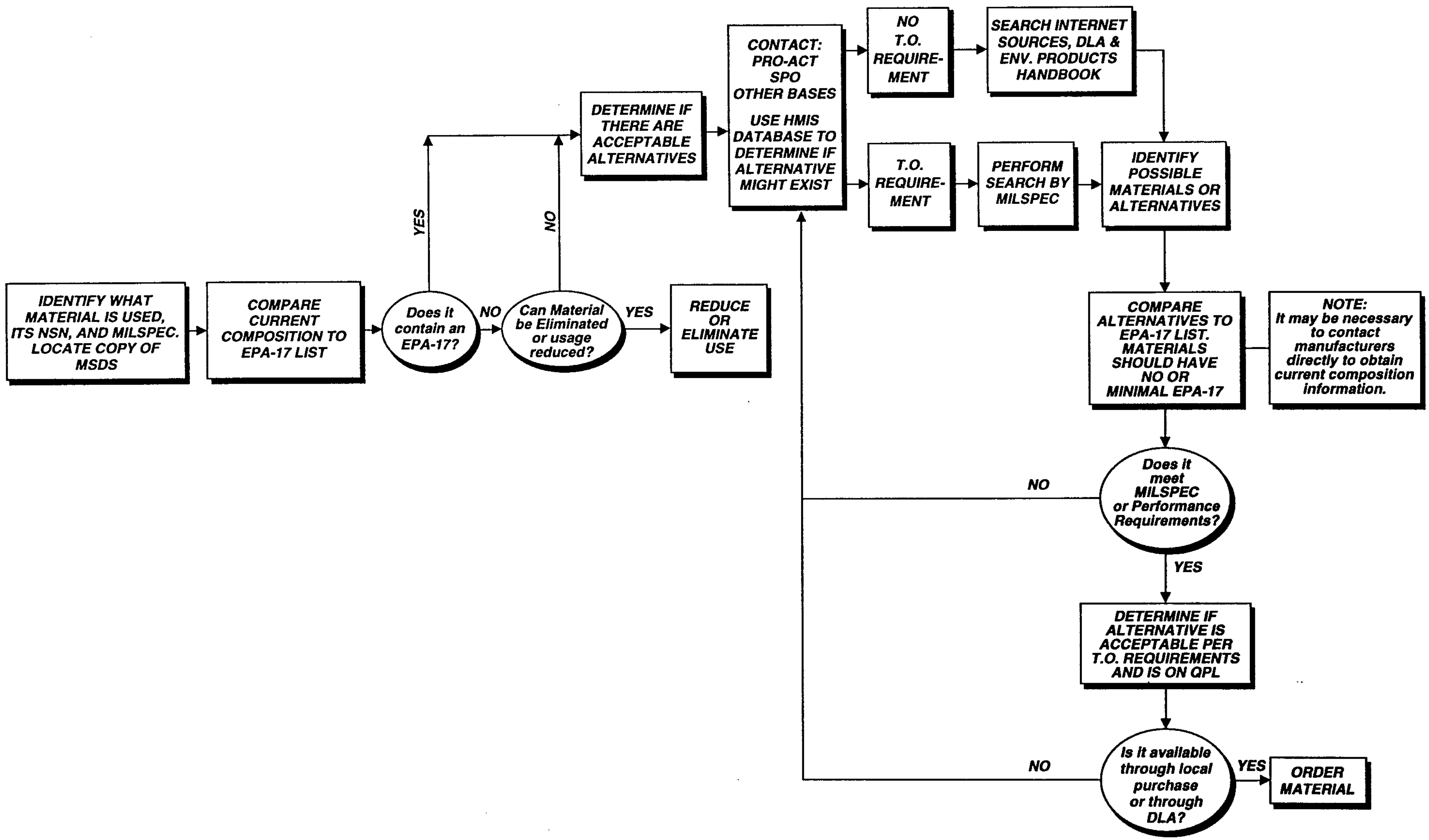
A summary of results and conclusions for the processes that utilize EPA-17 toxic chemicals or generate hazardous waste that were considered in the OA, and associated options and alternatives identified, are provided below.

EPA-17 Toxic Chemicals

Seven specific processes were considered in the OA that utilize EPA-17 toxic chemicals. In addition, one miscellaneous category was considered for general hazardous material usage in the shops.

Aircraft Painting
- 11 options considered

Figure 1. Identify Alternative Products



- 4 were recommended for immediate implementation without further evaluation:
  - Better calculation in mixing ratios
  - Better estimate of amount of paint needed
  - Train personnel on new technologies and reduction techniques
  - Use paint pot liners
- 3 were evaluated in further detail:
  - Use a substitute paint (no substitute for polyurethane currently identified)
  - Use unicoat paint technology
  - Use paint proportioning system

Aerospace Ground Equipment Painting
- 10 options considered
- 5 were recommended for immediate implementation without further evaluation:
  - Minimize area to be painted
  - Better calculation in mixing ratios
  - Better estimate of amount of paint needed
  - Train personnel on new technologies and reduction techniques
  - Use paint pot liners
- 3 were evaluated in further detail:
  - Use a substitute paint (0 substitute paints currently identified)
  - Use unicoat paint technology
  - Use paint proportioning system

Solid-Film Lubricant
- 3 options considered
- 1 was evaluated in further detail:
  - Use a less toxic chemical (none found, bulk application recommended)

MEK as a Wipe Solvent
- 3 options considered
- 2 were evaluated in further detail:
  - Use a substitute chemical
  - Use a less toxic chemical (13 substitute/less toxic cleaners identified)

Aerosol Paint Alternatives
- 7 options considered
- 3 were evaluated in further detail:
  - Use a paint stick instead of aerosol
  - Use low-VOC, high solid paint
  - Use vinyl lettering

Cleaner, Lubricant, and Preservative
- 2 options considered
- 1 was evaluated in further detail:
  - Use non-EPA-17-containing product (7 substitute products identified)

Corrosion Preventative Compounds
- 2 options considered
- 1 was evaluated in further detail:
  - Use non-EPA-17-containing product (21 substitute products identified)

Miscellaneous Hazardous Materials (lubricating oil, brake part cleaner, edge sealer)
- 3 options considered
- 3 were evaluated in further detail:

- Use substitute general purpose lubricating oil (11 substitute products identified)
- Use substitute brake part cleaner (9 substitute products identified)
- Use substitute edge sealer (1 substitute product identified)

Hazardous Waste Streams

Nine hazardous waste streams were considered in the OA.

Absorbents with Fuels/Oils

- 11 options considered
- 6 were recommended for immediate implementation without further evaluation:
  - Repair leaking equipment
  - Establish routine maintenance procedure to check for leaks
  - Monitor filling of tanks to minimize spills
  - Modify work procedures to minimize cleanup requirements
  - Use minimum quantity of sorbent required
  - Segregate sorbents
- 4 were evaluated in further detail:
  - Use a non-explosive wet vacuum
  - Burn sorbents for energy recovery
  - Compact sorbents to reduce volume and for waste oil recovery
  - Use higher-absorbency material

Paint and Paint Thinner Waste

- 10 options considered
- 7 were recommended for immediate implementation without further evaluation:
  - Discontinue routine use of solvent-based paint
  - Use remaining solvent-based paint for non-critical purposes
  - Develop written specifications for painting preparation
  - Evaluate procedures used to determine when to paint and how much paint to use
  - Use high-volume, low-pressure paint system
  - Better calculation in mixing ratios
  - Segregate solvents from paint
- 2 were evaluated in further detail:
  - Use substitute for solvent-based paint (no substitute for polyurethane currently identified)
  - Use plural-component system for two-component painting

Naphtha/PD-680 Waste

- 6 options considered
- 3 were recommended for immediate implementation without further evaluation
  - Install jet washers with biodegradable solvents
  - Discontinue use of solvent-based cleaners
  - Modify parts washers that use naphtha and PD-680 as necessary

Blasting Media

- 10 options considered
- 1 was recommended for immediate implementation without further evaluation:
  - Recycle blast sand
- 2 were evaluated in further detail:
  - Use blasting media other than sand, such as steel grit, glass bead, or Emerald Creek garnet
  - Use Blastox with sand

Jet Washer Rinseate

- 6 options considered

- 3 were recommended for immediate implementation without further evaluation:
  - Use less harsh cleaner
  - Evaluate basewide use of jet washers for consolidation of use
  - Evaluate operating procedures (time, detergent volume) to reduce metal recovery

Excess Hazardous Materials

- 5 options considered
- 5 were recommended for immediate implementation without further evaluation:
  - Inform personnel of non-hazardous substitutes
  - Develop written specifications for quantity of material required
  - Stock appropriate quantities of materials
  - Reuse leftover materials
  - Screen out unnecessary local purchases of hazardous materials

Paint Filters

- 6 options considered
- 4 were recommended for immediate implementation without further evaluation:
  - Discontinue dissolving styrofoam filters in MEK
  - Test filters before disposal to ensure they are hazardous waste
  - Develop written specifications for selection of paint filters
  - Develop written specifications for filter change-out procedures
- 1 was evaluated in further detail:
  - Segregate metal-based and non-metal-based paint operations

Rags with MEK

- 4 options considered
- 1 was recommended for immediate implementation without further evaluation:
  - Require written, performance-based technical justification for MEK use
- 2 were evaluated in further detail:
  - Use substitute chemical (13 substitute/less toxic cleaners identified)
  - Compact rags to reduce volume and to recover solvent

Batteries

- 3 options considered
- 2 were recommended for immediate implementation without further evaluation:
  - Convert from lead-acid to gel-cel batteries
  - Convert to rechargeable batteries

Conclusions

Significant reductions in the use of hazardous chemicals and the generation of hazardous waste streams are possible through chemical and process substitutions, minimization of hazardous chemical use, reuse or recycling, personnel training, or a combination thereof. Because new chemicals and products are constantly being developed, the P2 process must be ongoing. Important sources for continuing study include System Program Office (SPO) technical personnel, Hazardous Material Information System (HMIS) CD-ROM databases, vendors, Defense Environmental Network and Information Exchange (DENIX), PRO-ACT, EPA Enviroene Bulletin Board, Technical Information in Pollution Prevention Systems (TIPPS), and Defense Technical Information Center (DTIC).

AN INNOVATIVE APPROACH TO POLLUTION PREVENTION FOR U.S. ARMY RESERVE FACILITIES

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Abstract

The U.S. Army Reserve 90th Regional Support Command (RSC) has recently developed a Pollution Prevention (P^2) Program specific to the needs of the Army Reserve. The 90th RSC consists of 122 active facilities located over a five-state region: Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. For this project, the greatest concern in developing a comprehensive P^2 Program is the large geographic area and logistical issues present in the 90th RSCs five state area of responsibility. Consideration for federal and state waste management and transportation regulations, the number of facilities, and development of initiatives that are consistent with achievement of Army Reserve P^2 goals, are the overall prominent factors which influenced development of this program and its associated documents. This P^2 Program identifies the process for establishing the individual facilities current operational conditions for use in the generation of a command baseline against which future P^2 efforts can be measured. The selection process includes detailed technical and economic feasibility analyses performed to assist the command in determining which options provide the best return on investment and ease of implementation. As P^2 plan development was formulated to take into account the number of facilities and their locations, one innovative P^2 project, a mobile recycling unit for reconditioning used vehicle fluids, has been presented to the 90th RSC. This approach would enable all facilities to have access to these recycling units without the cost of purchasing separate units for each facility.

Introduction

As with most Department of Defense (DoD) facilities, the Army Reserve has begun integrating pollution prevention (P^2) as part of its everyday activities. The 90th RSC is one of twelve RSCs in the United States and is comprised of 122 active facilities in five adjoining states, location of these facilities is shown in Figure 1. Because of the number and distance between facilities, developing a cohesive P^2 plan and program such that all facilities can participate posed certain challenges.

The current initiative on pollution prevention is to meet state and national pollution prevention policy goals, reduce long-term liabilities of waste disposal, save money by reducing waste treatment and disposal costs, and protect public health and the environment. Pollution prevention is a cost-effective means of meeting environmental objectives in an era when U.S. Army facilities are simultaneously subjected to stricter standards for pollution control, public criticism of their environmental records, and declining budgets.

In an effort to accomplish the P² goals established by the U.S. Army, Army Reserve, DoD, and Executive Order 12856, the 90th RSC initiated an effort to establish P² baselines, identify and evaluate P² options, and develop projects that would be feasible for implementation as part of a comprehensive P² program. The following provides a discussion of these efforts and the approach to implementation across the 90th RSC.

P² Baseline

In order to develop the P² baseline, data was collected from each of the 90th RSC facilities to determine the annual material usage and waste disposal practices. A questionnaire was developed to enable standardization of information collected which included:

- Units located at each facility
- Operations at facility
- Materials usage
- Environmental Compliance reporting (EPCRA Section 313, biennial RCRA Hazardous Waste Report, air permits, etc.)
- Ozone Depleting Chemical (ODC) surveys
- Waste generation (motor oil, wastewater, municipal solid waste, etc.)
- Recycling programs

Site visits and telephone interviews were conducted to collect the above information using the questionnaire as a guideline. Once all of the data was collected from each of the facilities, the P² baseline was developed. The wastes being generated by each Army Reserve facility were divided into waste/usage categories such as ODC, Emergency Planning and Community Right-To-Know Act (EPCRA) Chemicals, Resource Conservation and Recovery Act (RCRA) Hazardous Wastes, and solid and other nonhazardous wastes. Selection of these categories was based on Army, Army Reserve, and DoD P² goals. The established baseline is used as a benchmark to measure all future P² progress.

Pollution Prevention Opportunity Assessments

Ten waste streams were selected for development of P² options based on the overall types and quantities of waste generated by the 90th RSC, those selected were as follows:

- Used oil
- Oil and fuel filters
- Parts washer solvent
- Antifreeze recycling
- Hydraulic oil and transmission fluid
- Brake fluid
- Contaminated fuel
- Municipal solid waste
- Washrack wastewater
- Ozone Depleting Chemicals.

Technical and economic evaluations were performed on options considered for reduction or elimination of the ten specified waste streams. In developing P^2 options, the location, number of facilities, maintenance unit reporting hierarchy and waste generation quantities was considered in order to meet the specific needs of the 90th RSC. Many of the facilities provide limited operator-level vehicle maintenance, therefore it was realized that purchase of waste or used material processing equipment at each of the 122 facilities would not be cost effective in many instances due to the minimal quantities generated.

Those P^2 options that were determined not to be feasible were immediately eliminated from consideration. P^2 options that had some merit were further evaluated to determine which P^2 options would be both cost effective and provide the greatest waste reduction. Evaluation of the P^2 options was performed using an unbiased ranking system with the following criteria:

- Preferred option hierarchy (management practices, equipment replacement, etc.)
- Worker safety
- Feasibility for implementation
- Cost
- Waste reduction.

Points were assigned (maximum of 10 for best option) to each of the criteria and tallied to determine the P^2 option with the best potential for implementation for each P^2 opportunity.

Pollution Prevention Projects

Per each waste stream, the option that rated the highest score through the ranking criteria was reclassified as a P^2 project deemed viable for implementation. Project development involved examining whether or not the project would enable the 90th RSC to meet its P^2 goals, applicable regulations, overall project cost and payback, and the barriers that may be encountered if the project were implemented. For each project, an implementation plan was developed to outline the steps needed to execute the project. The projects developed include:

- Solvent replacement for parts washers
- Mobile transmission fluid, hydraulic oil, brake fluid, and antifreeze recycling unit
- Management practices for contaminated fuel reduction
- Municipal solid waste recycling
- Management practices for wash rack wastewater reduction
- Used oil recycling
- Oil filter crushing and recycling
- Ozone depleting chemical phase out.

The mobile recycling unit proposed for reconditioning of used ethylene glycol antifreeze, 10W hydraulic oil, and possibly silicone-based brake fluid and automatic transmission fluid, is one project where the number and location of 90th RSC facilities was especially considered.

municipal solid waste P^2 assessment, 65 percent of centers and facilities throughout the 90th RSC are participating in local government sponsored recycling programs.

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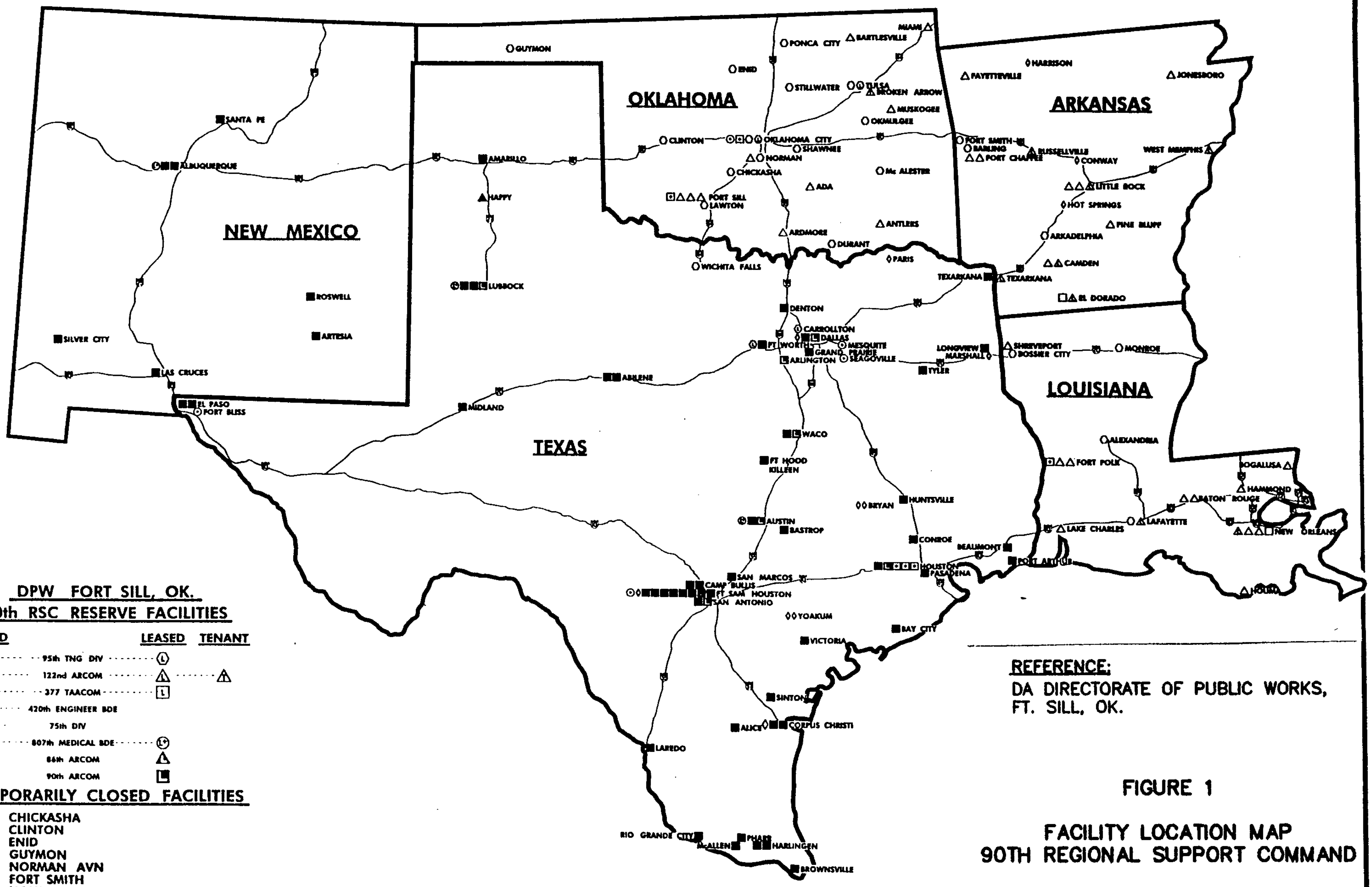

DPW FORT SILL, OK.
90th RSC RESERVE FACILITIES

OWNED		LEASED	TENANT
⬡	95th TNG DIV	Ⓛ	
△	122nd ARCOM	△	△
□	377 TAACOM	L	
◇	420th ENGINEER BDE		
⊡	75th DIV		
⊙	807th MEDICAL BDE	Ⓛ	
▲	86th ARCOM	△	
■	90th ARCOM	L	

TEMPORARILY CLOSED FACILITIES

CHICKASHA
CLINTON
ENID
GUYMON
NORMAN AVN
FORT SMITH
HOUMA

REFERENCE:
DA DIRECTORATE OF PUBLIC WORKS,
FT. SILL, OK.

FIGURE 1

FACILITY LOCATION MAP
90TH REGIONAL SUPPORT COMMAND

INTERNATIONAL TECHNOLOGY CORPORATION

Session XII
P^2 in Shipboard Operations

Session Chairpersons:

Mr. Charles Williams, SA-ALC/EMV
Dr. R. C. Wooten, Parsons Engineering

SESSION XIII
P^2 SUCCESS STORIES

SESSION CHAIRPERSONS:

Ms. Deneise DeHoyos, HQ AFCEE/EQT
Mr. Jay Williams, Roy F. Weston, Inc.

Compliance Through P2: A Success Story
US Navy Shipboard Solid Waste Management Program

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1.0 Background

The United States is a party to the 1973 International Convention on Prevention of Pollution from Ships. The 1973 Convention was amended to the MARPOL Protocol in 1978, and the combination is frequently referred to as MARPOL 73/78. Annex V of MARPOL 73/78, which pertains to shipboard solid waste disposal at sea, protects the ocean environment by prohibiting some discharges altogether (e.g., plastics), restricting some discharges to particular distances from land, and establishing "special areas" within which additional discharges limitations apply.

These "special areas" of water are so designated because their oceanographic characteristics and ecological significance require protective measures more strict than other areas of the ocean. Three areas are currently in effect for strict enforcement of particular regulations, and five areas are designated, but not yet in effect. The three areas in effect are the Baltic Sea, portions of the North Sea, and the Antarctic Ocean. The five areas designated, but not in effect, are the Red Sea, Black Sea, the Gulfs area (including the Persian Gulf and Gulf of Aden), the wider Caribbean (including the Gulf of Mexico), and the Mediterranean Sea.

The international community has long recognized that the physical and operational characteristics of warships pose special problems for strict compliance with MARPOL 73/78, which reasonably focuses on civilian vessels that are far more prevalent than warships on the world's oceans. Article 3 of MARPOL 73/78 recognizes the special nature of warships by not requiring strict compliance with the provisions of the Convention because of special considerations of mission effectiveness and operational flexibility.

MARPOL 73/78 was implemented for the United States in the Act to Prevent Pollution from Ships, or APPS, but with compliance requirements for warships. Annex V has been implemented in the United States by amendments to APPS and Section 1003 of the National Defense Authorization Act for Fiscal Year 1994 (DAA-94). Under DAA-94, Navy ships are required to come into full compliance with MARPOL Annex V or the Navy must notify Congress. As required by the DAA-94 for special areas,

- surface ships must eliminate all discharges of plastic by December 31, 1998;
- surface ships must comply with limits on discharges of other solid waste in special areas that are "in effect" by December 31, 2000.
- submarines must comply with both requirements by December 31, 2008.

2.0 Past Navy Compliance Efforts

Since the early 1980s, as part of its overall view toward pollution prevention, the Navy has been developing means to eliminate or mitigate discharge of solid waste from its ships. Through a combination of material substitution, source reduction, environmental education and management practices (such as the institution of the 3 day/20 day plastics rule, which deals with on-board retention of plastics), the discharge of plastic waste has been cut by over 70 percent. The Navy is continuing its efforts to reduce the amount of plastics brought on board.

The Navy has also pursued development of other technologies to help manage plastic solid waste at sea. This new Navy developed technology, which is now being procured and installed, will allow Navy surface ships to expand prevention pollution efforts by coming into full compliance with restrictions on discharge of plastic waste. The new technology that was developed is an on board plastics processor that compresses and sanitizes plastic waste for storage on board and retrograde. Funding for plastics processors is in place for completion of installation by the end of 1998.

The other Navy shipboard solid waste streams include biodegradable wastes, such as food, paper, and cardboard, and non-biodegradable wastes such as metals and glass. Current practices for the discharge of other solid waste are set forth in Chief of Naval Operations Instruction (OPNAVINST) 5090.1B. These practices include establishing minimum distances from land, and specifying the forms in which various types of solid waste can be discharged at sea. In addition, some vessels contain on board processing and destruction systems such as compactors and incinerators to help manage their waste.

3.0 Special Areas Compliance Plan

Recognizing the difficulty in achieving strict compliance with all requirements of Annex V, DAA-94 required the Navy to prepare a plan for compliance with the special area requirements of Annex V Regulation 5. The special area compliance plan was submitted to Congress in November 1996.

Critical factors in developing a shipboard solid waste management strategy include the composition, operation, and deployment of the US Naval fleet, waste generation rates and characterization, and current Navy solid waste management policies and practices. A thorough understanding of the ramifications of these factors enabled the Navy to identify several potential solutions for managing its shipboard solid waste. In addition to source reduction, the three areas of opportunity identified were:

- Store and retrograde (store all waste and return to shore for land-based processing and/or disposal);
- Process and discharge at sea; and
- Destroy on-board.

Once the Navy analyzed the primary technology alternatives appropriate for use in managing solid waste generated aboard ship, the next step was to determine the impact of installing, operating, and maintaining the identified equipment on board the various ships in the fleet.

To assess and distinguish the advantages and disadvantages of each shipboard solid waste management option under consideration, the Navy established a series of evaluation criteria :operational impacts, safety/quality of life, physical ship impacts, extent of compliance with APPS, environmental consequences, technical maturity, and cost.

4.0 The EO 12114/NEPA Process

An Environmental Impact Statement (EIS) was prepared to assess the environmental impacts of compliance plan alternatives. This was done pursuant to Executive Order 12114 -- Environmental Effects Abroad of Major Federal Actions -- and Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969, as implemented by the Council on Environmental Quality regulations, each of which establishes environmental review requirements for major federal actions. The provisions of Executive Order 12114 apply to major federal actions that occur beyond three nautical miles of the US, in the global commons, or within the jurisdiction of a foreign government. The provisions of NEPA apply to major federal actions that occur in the US and within three nautical miles from shore.

4.1 Scope of the EIS

Ships in the US Navy's fleet generate a variety of different waste streams, including solid waste, oily waste, hazardous waste, medical waste, sewage or "blackwater;" and graywater (wastewater from sinks, showers, laundries, and galleys). These waste streams are regulated by law and are managed by Navy waste discharge restrictions as defined in OPNAVINST 5090.1B (Chapter 19) and 5100.19C.

For the purposes of the EIS, the shipboard solid waste stream consisted of three general types of solid waste: biodegradable wastes (paper, cardboard, food), non-biodegradable wastes (metal and glass), and plastics. These are the types of solid wastes that need to be addressed with respect to MARPOL Annex V compliance. The EIS did not address other ship waste streams such as sewage, and oily, medical, or hazardous wastes.

The EIS also did not address the issue of solid waste discharges from submarines because submarine characteristics and operations are significantly different from surface ships (e.g., they have unique submarine characteristics include critical space, weight, shock, acoustic, and atmospheric-control requirements and criteria). However, subsequent to the surface ship study the Navy developed several options for submarines by evaluating and addressing reduction, retention, and discharge of solid wastes. This was documented in another report to Congress in December 1997. The Navy determined the most appropriate solid waste management strategy for submarines, which is both operationally and environmentally sound, to be the retention of plastic waste on-board and the continued use of trash disposal units (TDUs). The environmental impacts of submarine discharges were addressed in separate NEPA documentation.

4.2 EIS Alternatives

Pursuant to NEPA and the regulations of the Council on Environmental Quality or CEQ, an EIS must consider a range of reasonable alternatives to a proposed action. One alternative that must always be considered in an EIS is the "no action" or "do nothing" alternative. That is, the EIS must consider the impacts of <u>not</u> implementing the proposed action. Thus the EIS addressed the no action alternative and shipboard solid waste alternatives in the Navy's Report to Congress, as follows:

- **No Action Alternative** - Under the no action alternative, the Navy would continue its current shipboard solid waste disposal practices, with various discharge restrictions depending on the ship's location. For example, for non plastic solid waste, the Navy operates under various restrictions depending on whether the ship is inside or outside of a MARPOL in-effect special area. In in-effect special areas food waste is not discharged less than 12 nm from land.

- **Store and Retrograde Alternative** - The store and retrograde alternative focuses on technologies that would permit the storage and retrograde of all non-food waste, either on board the generating ship or by service force ships. These included study of refrigeration, processing, compaction, odor barrier bags and other means to facilitate the storage and retrograde of solid waste for disposal on shore.

- **Process and Discharge Alternative** - Plastics processors would be used for surface ships and the plastic stored for retrograde; food wastes would be discharged overboard. The use of pulpers for processing paper and cardboard, and shredders for metal and glass, would be implemented. The processed material would then be discharged overboard.

- **On Board Destruction Alternative** - The on board destruction alternative focuses on technologies that would result in virtually complete destruction of waste aboard the vessel. The waste destruction technologies could include incineration or more technologically advanced thermal destruction, such as plasma arc pyrolysis. Under this alternative, the proper handling of any residue would mean its retention on board.

- **Special Areas Compliance Plan** - The Special Areas Compliance Plan, identified in the Navy's Report to Congress, is the Navy's preferred alternative for management of shipboard solid waste. In combination with plastics waste processors, the Navy would install pulpers and shredders on all vessels the size of frigates or larger (roughly 200 ships). These include such ships as frigates; destroyers; cruisers; amphibious helicopter assault ships; aircraft carriers; and fleet oilers and supply ships. The Navy would to retain and retrograde waste on smaller ships and patrol craft (roughly 55 ships). These include: mine countermeasure and mine hunting ships; rescue, salvage and towing ships; coastal patrol boats, and landing craft that have a limited range and mission duration.

5.0 EIS Study Findings

5.1 No Action Alternative

The impact of the no action alternative on the shipboard environment would continue to be severe with respect to quality of life, mission readiness, and damage control. Floating marine debris and beach litter would continue to be a problem. Finally, this alternative does not comply with APPS and does not contribute to the Navy's pollution prevention efforts.

5.2 Store and Retrograde Alternative

Although the store and retrograde alternative complies with APPS and makes a positive contribution to the Navy's pollution prevention efforts, implementation of the store and retrograde alternative for existing ships would adversely impact the shipboard environment by further reducing already cramped crew berthing and living

space to accommodate equipment and dedicated storage space. Additional Combat Logistics Force (CLF) ships would be required due to the amount of waste that would be retrograded. In addition, existing CLF ships would need to be physically modified, thereby removing some of their operational and living space. The store and retrograde alternative presents a number of logistical problems including increased frequency and duration of underway replenishments (UNREPs) and increased frequency and duration of port calls.

Costs to implement the store and retrograde alternative would be significant. The total costs to the fleet would be a minimum of $1.0 billion. These costs do not reflect the reinstallation of displaced equipment and crew, which would be significant.

5.3 Process and Discharge Alternative

No significant shipboard impacts were projected to result from the installation of pulpers and shredders. Odor impacts from storing food-contaminated wastes would be eliminated or reduced. Prompt removal of all wastes would make storage of wastes in inappropriate spaces unnecessary; personal crew space would not be affected on any class of ship; and only in one instance would a portion of crew shared space be lost. This alternative would enhance mission readiness for Navy ships since waste disposal could proceed during flight operations. Flight decks, hangars, and other operations space would not be cluttered with the temporary storage of solid waste.

The pulpers would create a mixture of seawater and pulped paper/cardboard for overboard discharge. The discharged slurry is 0.3 to 0.5 percent solids by weight and consists mainly of cellulose. Studies showed an immediate 100,000:1 dilution when discharged into the wake of a ship. At concentrations expected after discharge, bioassays showed no detrimental effect in any marine organism studied. Shredders would create a sinkable bag of shredded glass and metal for overboard discharge. Studies showed that the bags sink rapidly, become partially buried on the bottom, will not move towards shore, and become colonized by various types of marine organisms. Over time, the shredded metal oxidizes and disintegrates.

The cost impacts of acquiring, installing, and operating the pulpers and shredders for the process and discharge alternative would be significantly lower than costs for the other equipment alternatives. The total cost for the fleet would be $340 million.

The process and discharge alternative would be implemented outside of special areas, as well. The process and discharge alternative does not comply with APPS but does contribute to overall pollution prevention efforts.

5.4 Onboard Destruction Alternative

Significant shipboard impacts were identified for all ship classes. The space required for the installation of thermal destruction equipment would result in reduction in crew or troop berth space; this force reduction would in turn negatively impact the ship's mission capability. Mission readiness would also be impacted on all ships with flight operations, because of incinerator emissions. A modeling study of shipboard incinerator emission indicates that the air quality impacts from ship incineration would not be significant.

Implementation of the on-board destruction alternative would entail major cost impacts. The total costs to the fleet would be a minimum of $1.2 billion. These costs do not reflect the reinstallation of displaced equipment and crew, which would be significant. The on-board destruction alternative would not be implemented outside of special areas. The on-board destruction alternative complies with APPS and, is also beneficial from a pollution prevention standpoint.

5.4 Compliance Plan

Under the Compliance Plan, the Navy would install paper/cardboard pulpers and metal/glass shredders on frigates and larger ships (roughly 200 ships). Small ships and coastal craft whose missions are of relatively short duration (roughly 55 ships) would store solid waste in odor-barrier bags until returning to shore or for transfer to another ship. Plastics waste processors would be installed on approximately 200 ships to manage plastics wastes. Thus, for larger ships, impacts of the compliance plan would be those described for the process and discharge alternative. For smaller and coastal vessels, mission readiness would be potentially reduced with storage of unprocessed solid waste, although this impact should not be significant given the fact that these ships operate close to shore and have more frequent off-loading opportunities.

6. Results

Congress concurred with the Navy's findings and proposed plan, as reflected in the National Defense Authorization Act for Fiscal Year 1997. This law included specific language allowing Navy ships that cannot comply with MARPOL Annex V to discharge the following solid wastes in the "special areas":

- Pulped paper, cardboard, and food waste that can pass through a screen with 12-mm openings (beyond 3 nm from land)
- Metal and glass that have been shredded and bagged to ensure negative buoyancy (beyond 12 nm).

The Navy was not provided with any relief from the MARPOL Annex V worldwide ban on the discharge of plastics (as implemented in APPS).

Pursuant to these laws, the Navy is installing plastics waste processors on frigates and larger ships to meet the December 31, 1998 legislative deadline. The Navy is also procuring pulpers and shredders for installation on these ships to meet the December 31, 2000 legislative deadline. Although not required to by law, the Navy has committed to operating its new shipboard solid waste pulpers and shredders everywhere, not just in the MARPOL "special areas." This will result in benefits to the marine environment that exceed the MARPOL Annex V objectives.

REDU
CTION OF HAZARDOUS WASTE METALS SLUDGE AT HILL AIR FORCE BASE

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INTRODUCTION

Reduction of hazardous waste generation and disposal is an ongoing primary goal at Hill Air Force Base. It has been a major focus of the hazardous waste management program since 1985 and Slide 4 shows the results of those efforts through 1997. Note that a significant portion of the disposal is identified as Industrial Wastewater Treatment Plant (IWTP) sludge. This sludge has been disposed as a hazardous waste because it is a listed waste, number F006, wastewater treatment sludges from electroplating operations. It is listed due to the hazardous constituents; cadmium, hexavalent chromium, nickel, and cyanide (complexed). The sludge is also considered a hazardous waste because it often fails the TCLP procedure for cadmium and chromium and is, therefore, a characteristic hazardous waste with the waste numbers D006 and D007.

It was apparent early last year that in order to meet the hazardous waste reduction goal for 1999 it would be necessary to reduce the sludge production and disposal. Therefore, a project was organized to accomplish this and the following major pieces were defined.

Improve process control to reduce water content
Regulations review to evaluate applicability of F006 waste number
Establish a mass balance for cadmium and chromium
Research practices at other similar shops
Separate non-reactive solids into separate waste stream
Reduce input of cadmium and chromium from the cleaning and electroplating shops

This paper describes a project that has accomplished a reduction of the cadmium and chromium input from the cleaning and electroplating shops to the main IWTP process and the consequent reduction in the production of the final hazardous waste sludge. The objective was to evaluate and test the feasibility of separation of the heavy metals, chromium and cadmium, in the pretreatment module of the IWTP rather than introducing them directly into the main plant flow. The desired result was reduction of the inflow of these two heavy metals into the IWTP equalization tanks to values as low as technically and economically feasible.

BACKGROUND

The industrial wastewater collection system at Hill Air Force Base includes:

Wastes from metal finishing operations
Wastes from electroplating operations
Wastewater from washing of aircraft
Wastewater from painting operations
Backwash from the oil sorbent and activated carbon units
Filtrate from the sludge dewatering facility
Supernatant from the sludge holding tank
Flight line washdown infiltration
Stormwater flow
Contaminated groundwater from on site remediation operations

The treatment plant is designed for an average flow rate of 400 gpm and a maximum flow rate of 600 gpm. It operates as a point source under a NPDES permit discharging to the local sewer district and must meet the Categorical Pretreatment Standards under 40 CFR 403.6. The effluent must meet standards for cyanide, pH, oil and grease, suspended solids, total toxic organics and a

list of eleven metals including cadmium and chromium. These are the major metal contaminants that the process is designed to remove. This is accomplished by pH adjustment with sulfuric acid and addition of sulfur dioxide followed by addition of sodium hydroxide, which precipitates the heavy metals as oxides. These solids are then separated by flocculation, clarification, filtration and drying to become the hazardous waste sludge that is being disposed. A mass balance study was done last summer to provide better data on the sources of cadmium and chromium in the influent to the IWTP. Slide 5 shows the relative amounts and the flows in a simplified schematic. This study put some numbers to the already known fact that the major contributors were the electroplating and surface preparation processes in the landing gear maintenance operations of the Commodities Directorate. It also quantified the proportion of these two metals that were coming as concentrated waste solutions, in carboys, to the batch pretreatment process at the IWTP as compared to the mass coming in the continuous flows into the main portion of the plant.

APPROACH

The approach recognized that a significant portion of the total cadmium and chromium inflow from these major sources was first coming into the pretreatment process. If changes could be effected in the batch pretreatment to remove these two metals prior to entry into the main IWTP flow significant benefits appeared to be possible. It was also anticipated that if these two metals could be separated as high concentration solids it might be possible to reclaim the metal values by recycling or treatment. Past attempts to reclaim the metal values from the IWTP sludge were unsuccessful due to the very low concentrations of the metals in that sludge.

The project was defined to include the following:

Assess and evaluate the current pre-treatment process for chromium and cadmium including data on flows and composition of flows.

Provide a plan for obtaining the additional data needed and obtain the data.

Install two filter units that had been obtained in anticipation of this use and test their capability to filter out the cadmium solids.

Evaluate available precipitation and separation technologies for chromium and recommend changes to incorporate the best candidate in the pretreatment process.

Utilize equipment and materials currently in use to the maximum extent feasible.

Perform bench /pilot scale testing of the proposed process changes.

Make changes to the pre-treatment process piping and equipment necessary to test the proposed changes while maintaining plant operation.

Conduct testing, evaluation and demonstration of the process changes on site, train the IWTP operators, and transfer operations to them.

Provide documentation including operation and maintenance manuals.

Investigate recycle or treatment of the separated solids to reclaim the metal values.

At the beginning of the project Hill Air Force Base Environmental Management (EMC) and Radian International recognized the importance of forming a team with all of the significant stakeholders involved. The team included the people from the Commodities Directorate who generate the major proportion of the waste and the people at the IWTP who process the waste, including the engineer, supervisor and operators. Weekly teleconferences were held involving the affected stakeholders and interaction between project engineers and IWTP operations people was routine.

cadmium being treated in the pretreatment process can be removed before it ever sees the IWTP main treatment process.

CHROMIUM SEPARATION EVALUATION, TESTING AND DEMONSTRATION

This part of the project was not as straight forward as the cadmium separation, which was already in the form of a precipitate and just had to be filtered. The chromium is in the form of a concentrated solution that must first be treated to form chromium containing solid and then the solid separated by filtration. The first step was to evaluate the existing processes for chromium reduction and precipitation and choose the one that made the most sense for implementation at Hill. One of the major factors in the decision was the capability to maximize the use of existing equipment, chemicals and personnel for the chosen process. Another significant factor was the ability to make the process equipment changes without disruption of the ongoing IWTP process. Available technologies were screened and seven possible processes were listed. Two of these were selected for final evaluation, which included bench testing in the laboratory. The two final candidates were a) the conventional method, most widely used, which uses sulfur dioxide and sodium hydroxide, and b) the sulfide method which uses sodium sulfide and ferrous sulfate. Results of the bench tests showed that both methods achieved chromium removal above 99.99%. However, due to other factors the conventional method was chosen. The advantages of this method are summarized in slide18. The sulfide method has advantages also, but more disadvantages, which are summarized in slide 19. The conventional treatment method was clearly the choice.

The first step in the treatment is the reduction of hexavalent chrome to trivalent chrome, which occurs by the following first order chemical reaction:

3SO2 + 2H2CrO4 + 3H20 -->
Cr2 (SO 4)3 + 5H2O

This reaction occurs as sulfur dioxide gas is diffused into the acidic concentrated chromium solution.

The second step is the formation of the solid chromium hydroxide by the following first order reaction with sodium hydroxide:

Cr2(SO4)3 + NaOH -->
Cr2(OH)3 + Na2SO4

Implementation of the treatment process required additional piping to add sulfur dioxide and sodium hydroxide to the existing concentrated chromium solution tank. Piping revisions were also made so that the processed solution could be filtered by the two filter presses. Also, a pump to deliver sodium hydroxide was installed. A schematic for the combined processes is shown in slide 20. A schematic layout is shown in previous slide 11.

The first reaction is initiated within the chrome tank, shown in slide 21, by opening the valves between a 1-ton sulfur dioxide (SO2) cylinder stored in the cylinder room (main floor of Building 10581) and the chrome tank. Sulfur dioxide is added for several days until chrome reduction is complete, as indicated when ORP readings gradually change from around 800 or 900 mV to less than 460 mV (at pH less than 1) or less than 400 mV (at pH less than 1.5). This is

confirmed by laboratory tests that hexavalent chrome is less than 1 ppm. The photo in slide 22 shows the batch near the end point. Once reduction is complete, the SO2 valves are closed. Operators carefully monitor the cylinder weight, ORP levels, and any leakage of SO2.
Now sodium hydroxide(caustic) is added to initiate the second reaction. The caustic pump is located in the basement of Building 10581. The 25% caustic solution (by weight) is added until the pH changes from below 1 to between 7.2 and 8.4. A pH of 7.5 is the ideal end point. Reaching this end point generally takes between 8 and 48 hours, depending on the quantity and concentrations of the initial chrome solution. Aqua -green slurry will form. Water may need to be added to keep the solution from solidifying and overloading or damaging the mixer.
When the pH has reached near 7.5, filtering may begin using one or both of the filter presses. The filtrate is sampled to confirm proper removal of chrome metals.
Two batches of chromium, with an estimated total volume of 4,350 gallons of chrome solution, were treated and filtered. Chemical addition and total treatment time correspond fairly well to the initial concentrations. Batch 2 was larger and more concentrated in both hexavalent and total chrome, and required correspondingly higher quantities of sulfur dioxide, caustic, and filtering time.
Based on the estimated yearly quantities approaching 20,000 gallons of chrome solution, the system will likely require use of one filter press approximately 4 months per year. This filter press usage could be reduced further if cake discharges were performed more frequently. With the concentrated Batch 2, the filter press filled every 5 minutes but due to manpower limitations the cake was dropped much less frequently.
The chrome pretreatment process effectively removed both hexavalent and trivalent chrome. Initial chrome concentrations up to 5 percent solution (50,000 ppm) were effectively removed to below 20 ppm in the filtrate. Filtrate readings lower than 1 ppm are anticipated during normal operation.
The filter cake(sludge) has no free liquid and is 31% solids. The solids consist of 13% chromium oxide(in hydrated form), 8.5% phosphates, 4% other metals and 4.5% sulfates.
In the first batch 7 drums of sludge were produced in 4 days and in the second batch 64 drums were produced in 30 days. As in the case of the cadmium sludge, this sludge is high in chromium content to make it feasible to recycle it. And this test demonstrated that the chromium in the concentrated solutions can be reduced from over 50,000 ppm to less than 20 ppm.
Several lessons were learned which will be implemented to improve the equipment and procedures for the continuing pretreatment process.

PROVIDE DOCUMENTATION AND TRAIN

The implementation of these changes in the pretreatment process at the IWTP will require changes in procedures for the plant operators. A detailed and well organized Operation and Maintenance Manual was provided for their use. The operators were trained in the procedures as the project progressed and therefore know how to operate the new processes. The new manual will be a valuable training tool for new operators in the future.

RECYCLE NEW SLUDGES

Since the objective of the project was to reduce the disposal of hazardous waste sludge, the recycling of the two new sludges was investigated. They are clearly hazardous wastes. Vendors were found who professed the ability to recycle the sludges to reclaim the metal values so

samples and profiles were provided to the two that appeared most promising. The selection process resulted in only one vendor who was capable of recycling both cadmium and chromium sludges and who met all the regulatory criteria. The selected vendor is U. S. Filter Recovery Services Inc., of Roseville, Minnesota. They treat the sludges by blending and drying, if necessary, to meet the feed stock specifications for the high temperature metal recovery(HTMR) process at Horsehead Resource Development Co. in Chicago. The flow chart in slide 23 illustrates the process. USEPA considers HTMR to be the best recovery option for metal bearing hydroxide sludge. One of the products produced by Horsehead, which utilizes the cadmium from our sludge, is lead/cadmium concentrate which is sold for further refinement and use in the manufacture of batteries and other products. Another of their products which utilizes the chromium is called Iron Rich Material(IRM). This product finds uses as kiln clinker necessary for the manufacture of cement and as an economical asphalt aggregate. Slide 24 illustrates the Horsehead process. The net result for Hill is that the cadmium and chromium are beneficially used and not disposed to landfill as a hazardous waste.

BENEFITS

The benefits of this project are summarized on slide 25. The cost to purchase, install and operate the equipment for the project was $100,000 which was provided from Pollution Prevention funds. No additional personnel were required for operation so no additional labor costs are assumed. Chemical usage is reduced. Since the cadmium solid is removed by filtration, it is not necessary to dissolve it by acid addition in the main plant. This saving in sulfuric acid usage was not measured during the project. Similar reductions in chemical usage were anticipated by treating the chrome concentrated solution rather than first diluting it with other wastewater streams. Quantifying the chemical savings was complicated by the fact that an upgrade of the IWTP main process came on-line in June 1997, simultaneously with the startup of the pretreatment separation process. Chemical savings observed are summarized in slide 26. It is likely that a large portion of the sulfur dioxide savings observed at the plant directly resulted from treating (reducing) a significant portion of the chrome in a concentrated batch rather than in a diluted form. An estimated $25,000 per year is saved in SO2 usage with the pretreatment chrome separation process.

The main IWTP sludge volumes sent off site have decreased since July when the pretreatment process was initiated. Monthly values averaged above 28 tons per month prior to July 1997, and have averaged closer to 10 tons per month since then, or a 64% reduction. The reason has not been defined but it appears to be due to the pretreatment process changes. The current disposal cost is $0.21 per pound. This equates to an annual disposal cost of approximately $140,000 per year prior to installation of the filter presses. The reduction represents potential net savings of $91,000 per year for disposal of sludge from the IWTP main process.

Over the same six-month period, approximately 30,000 pounds of pretreatment sludge have been drummed and sent for recycle as mentioned previously. At a cost of approx. $0.50 per pound this equates to an approximate recycle cost of $30,000 per year.

The overall net savings in sludge disposal cost, therefore, is approx. $61,000 per year. This makes the total savings for chemical usage and sludge disposal approx. $86,000 per year.

The removal o f the cadmium and chromium in the pretreatment process may reduce the content of these metals in the final sludge such that it is no longer a characteristic hazardous waste. This is yet to be proven based on a more extensive mass balance study now underway. If this is the

case and the F006 listed waste code can be removed as a result of other efforts now going forward the final sludge will no longer be a hazardous waste.

A less tangible but real benefit is the reduced liability resulting from recycling the sludges into useful products rather than placing them in hazardous waste landfills.

Another benefit of the project was a reduction in the cadmium content of the IWTP water effluent. It came at a very opportune time when the effluent standard had been reduced and without this project the limit would probably not have been achieved.

SUMMARY

The project demonstrated that cadmium and chromium can effectively be removed from the influent to the IWTP by minor changes in the pretreatment process. Removing these metals as solids and recycling them reduces the total sludge quantity and cost for disposal. Further, the final IWTP sludge may no longer be a characteristic hazardous waste. A rigorous mass balance study is now underway to determine the regulatory status of the sludge.

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LITHIUM BATTERY RECOVERY AND REUSE PROGRAM

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INTRODUCTION:

Fort Polk is located in west central Louisiana and is currently the home of the Joint Readiness Training Center (JRTC), the 2nd Armored Calvary Regiment, the FORSCOM Redistribution Center (operated by Martin-Lockheed), and the garrison's Warrior Brigade. Fort Polk covers 198,963 acres - 98,125 of which belong to the United States Forest Service and it makes up part of the Kisatchie National Forest.

The JRTC mission of training light infantry soldiers in low-intensity conflicts involves the addition of a brigade-sized task force to the installation each month. The aggressive training mission of the JRTC and Fort Polk presents extraordinary challenges to protecting the environment without mission impacts. Visiting and resident soldiers at the JRTC utilize a wide variety of batteries in military equipment during the rotational exercises. The Army currently spends approximately $70 million annually on the purchase of all batteries. Lieutenant General Reimer, Chief of Staff of the Army, has established a 50% reduction in the cost of battery procurement as an Army wide goal. The JRTC & Fort Polk have, in turn, established a program to help in the reduction of battery expenditures and waste disposal costs.

The use of one specific battery has increased dramatically over the last 18 months. This battery a BA 5590 is a 12-volt lithium battery, with 10 lithium cells and weighs approximately 2.5 pounds. The purchase price for these batteries is $65.00 each; the disposal cost as a hazardous waste is $9.22 each.

The BA 5590 is used to power not only communications equipment, but also to power the SAWE II MILES (Simulated Area Weapon Effect [II] Multiple Integrated Laser Engagement Simulator) which locates individuals and equipment on the battlefield. Historically, the use and disposal of these batteries has been managed at the unit and soldier level. However, in 1996 and 1997, the JRTC began fielding the SAWE II MILES equipment and saw a steep increase in the numbers of used batteries being generated and processed for disposal by visiting rotational units. Due to the inherent safety issues surrounding the use and discharge of these batteries, it has been unrealistic for the visiting units to accomplish the discharging, testing, and disposal required for batteries used during their rotations. The rotational units are at Fort Polk for approximately 3 weeks, with only 5-7 days available for clean-up following the exercise. During the time period April 1997 - April 1998, the JRTC used over 24,000 lithium batteries. The increasing use of the SAWE II MILES will result in even greater numbers as the year goes on. As a result of the increased usage and the rather complex testing and disposal procedures, the environmental staff dedicated personnel to oversee the process at the North Fort Polk Consolidated Solid Waste Collection Facility. These individuals collect and process all batteries used during the rotation.

MATERIALS & METHODS:

The following list of materials are being used for management of the BA 5590 lithium batteries:
BA 5590 Lithium sulfur dioxide batteries (NSN:6135-01-36-3495) $65.00 each
Energage LS 94 State-of-Charge-Tester (NSN: 6625-01-370-8278)
Standard Multimeter (Voltmeter)
Small flat tip screwdriver or similar device
Paint pen or permanent marker
Tracking form
Well ventilated storage area

Batteries are first placed on the state of charge tester to determine their life span. Those batteries determined to have more than 70% of their life span remaining are stored and issued out upon request. Batteries with readings less than 70% are then further processed. Batteries (older versions) which do not have a complete discharge device (CDD) are disposed of as a hazardous waste, for ignitability (D001) and reactivity (D003). Batteries having a CDD are than activated. To activate a CDD you must remove the clear plastic strip covering the CDD then using a small flat tip screw diver or similar device, you press down on the small metal activation switch. These batteries are then dated and allowed to set for 5 days in a well-ventilated area; each battery must be separated by at least two inches on all sides. Once the 5 days have passed the batteries are again tested this time using a standard multimeter. If the voltage reading is below 4, the battery will be marked with that reading along with the initials of the individual conducting the test. The battery is then logged by serial number and is considered non-hazardous waste and can be disposed of in the installation refuge. Those batteries exceeding the 4 volts have faulty CDD's and must be disposed of as a hazardous waste, D001 and D003.

RESULTS:

On average, 29% of the batteries processed have greater than 70% of their life span remaining and may be re-issued. Re-issue of the BA 5590 lithium batteries has resulted in an annual cost savings to the Army of well over $280,000. Another $190,000 is saved annually (cost avoidance) with the processing of the batteries and disposal of 58% as non RCRA wastes. This left only 13% of the batteries needing to be disposed of as a hazardous waste. Disposal costs average $9.22 each (DRMO disposal, and proper packaging). Table 1 indicates the costs associated with BA 5590 battery management prior to implementing the state-of-charge testing and battery re-issue.

TABLE 1. PREVIOUS MONTHLY LITHIUM BATTERY PROCESSING

COST CATEGORY (ACTIVITY) BATTERIES PROCURED LIFECYCLE COST* ANNUAL COST MILES BATTERIES 1500 each rotation $74.22 $1,113,300 SINGAR BATTERIES 900 each rotation $74.22 $667,980 320 MAN HOURS @ $10.00 ea. $3,200 TOTALS 2400 each rotation $1,784,480 * Life cycle costs are the cost of procurement and disposal. Each battery costs $65.00 to procure; hazardous waste disposal cost is $9.22 per battery.

TABLE 2. CURRENT MONTHLY LITHIUM BATTERY PROCESSING

COST CATEGORY (ACTIVITY) BATTERIES PROCURED LIFECYCLE COST* ANNUAL COST MILES BATTERIES 1500 each rotation 66.20 $993,000 SINGAR BATTERIES 465 each rotation 66.20 $302,976 620 MAN HOURS @ $10.00 ea $6,200 TOTALS 1965 each rotation $1,302,176 *Life cycle costs are the cost of procurement and disposal. Each battery costs $65.00 to procure; hazardous waste disposal cost is $9.22 per battery. Only 13% of the batteries are disposed of as hazardous waste, therefore, disposal costs are reduced by 87% (averages $1.20 each).

TABLE 3. LITHIUM BATTERY COST AVOIDANCE REALIZED EACH MONTH AT JRTC & FORT POLK

Cost Savings/Cost Avoidance Data Dollars/month of JRTC Rotations Battery Procurement Avoidance $28,275 Battery Disposal Avoidance $19,772 Increased Personnel Management Costs ($3000) TOTAL $45,047

Note that Table 1 indicates that all that all lithium batteries were managed and disposed of as hazardous wastes. In Table 2, the results of two cost avoidance processes are evident. First, all lithium batteries are tested and reused whenever possible. Approximately 29% of the batteries are reused. Secondly, any battery not showing at least 70% of its life-span is further processed to determine if they are to be disposed as a hazardous waste or a solid waste. As a result, only 13% of the batteries have been disposed of as a hazardous waste.

Increased management of lithium BA 5590 batteries has paid off at the JRTC. As evident in Table 3, the JRTC is realizing over $45,000 in cost avoidance during each monthly rotation. The JRTC has averaged 11 rotations annually during the past two years. The cost avoidance realized by the program have been secondary to the benefits seen in environmental compliance, waste reduction, and worker health and safety. Having trained personnel working with the batteries has reduced the potential injury to soldiers during the testing and handling. These are dangerous batteries and violent discharges do occur. The personnel working with the batteries are trained to operate the equipment safely and utilize personal protective equipment to avoid exposure to the acid gases in the event of a violent discharge. Soldiers are instructed not to activate the CDD prior to battery turn in, thus reducing the potential chances that the heat generated during the routine discharge process could ignite a fire.

Other installations attempting to implement a system like this must be aware of the Army's guidance on the safe management of lithium batteries. This is available through the following publications: Technical Bulletin (TB 43-0134), Battery Disposition and Disposal, Headquarters, Department of the Army,1 October 1996 and Logistics Engineering Management Power Sources Team, Ground Precautionary Message (GPM-96-012). The GPM's provide necessary information on the proper disposal of lithium batteries as well as safety information. Several battery vendors are available, PCI (Power Conversion Inc), Ballard, and SAFT. It should be noted that all batteries included in this study were manufacture by PCI. Safety issues identified

in the GPM's precluded reuse of any SAFT BA 5590's. For more information on this project contact Mr. Jeffry Ross, 318-531-6578 (DSN 863-6578) HYPERLINK mailto:rossj@polk-emh2.army.mil rossj@polk-emh2.army.mil or Christine Hull, Ph.D., 318-531-6084 (DSN 863-6084) HYPERLINK mailto:hullc@polk-emh2.army.mil hullc@polk-emh2.army.mil or visit the JRTC & Fort Polk web site: HYPERLINK http://www.jrtc-polk.army.mil/index.htm http://www.jrtc-polk.army.mil/index.htm .

*Jeffry P. Ross is employed by Radian International and provides RCRA EPCRA and technical support to the JRTC & Fort Polk Environmental and Natural Resources Division. Christine G. Hull, Ph.D. is a DA civilian employee and serves as the installation's Hazardous Waste and Hazardous Material Manager, Solid Waste Manager, and P2 Coordinator.

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Session XIV
Recycling/Composting

Session Chairpersons:

Ms. Nancy Carper, HQ AFCEE/EQT
Ms. Lynn Kucharski, TAMS Consultants

THIRD ANNUAL JOINT SERVICE POLLUTION PREVENTION CONFERENCE & EXHIBITION

RECYCLING, IT'S STILL THE ONE!

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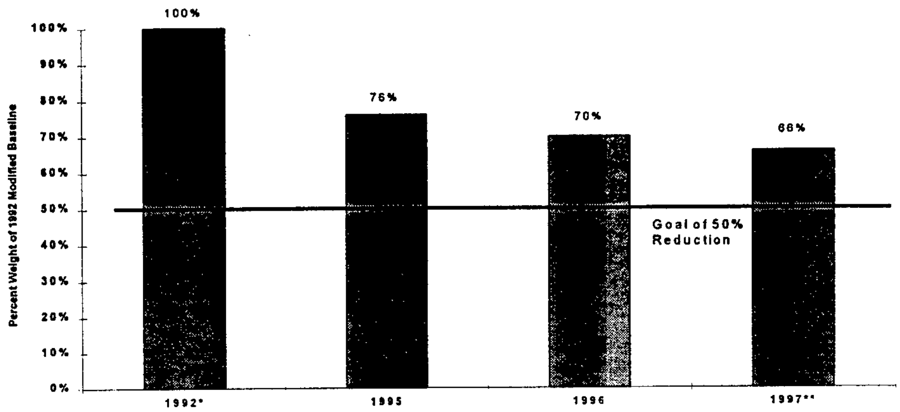
In early 1997, a solid waste management plan (SWMP) was undertaken at F.E. Warren AFB to attain compliance with AFPD 17-4, Pollution Prevention Plan of Action, calling for a 50-percent reduction in municipal solid waste disposal from a 1992 baseline. In 1994, a comprehensive solid waste opportunity assessment (OA) (including lots of dumpster diving, adequate to perform a statistically valid analysis) had been performed. Recommendations were made and implemented, however, the base had thus-far only achieved a recorded 30-precent reduction and expected to reach a 34% reduction by the end of 1997 as shown in Figure 1. However, this still fell short of the goal of 50% reduction by the end of 1997.

RECYCLING IS STILL THE ONE (Continued)

FIGURE 1
TREND OF THE REDUCTION OF SOLID WASTE FROM 1992 THROUGH 1997



* Weight is the 1992 Modified Baseline
** Weight for 1997 is projected for the entire year based upon the first six months of 1997

Parsons Engineering Science, Inc. (Parsons ES) was contracted to prepare a SWMP for F.E. Warren Air Force Base (AFB) (the Base) under Contract Number F41624-94-D-8136, Delivery Order Number 0062, between the Air Force Center for Environmental Excellence and Parsons ES. The purpose of preparing the SWMP was to ensure compliance with [illegible] Figure 2 [illegible] nd to bring F.E. Warren AFB int[illegible] Waste Components in the Combined Solid Waste Stream This instruction mandates that each installation have a solid waste management program. The SWMP prepared was the first step in fulfilling the requirements of the program by addressing SW handling, storage, and collection; disposal; recordkeeping and reporting; and pollution prevention (P2).

Parsons ES performed a limited validation study (including limited dumpster diving) of the solid waste stream, looking specifically for recyclable materials which escaped the recyc[illegible] Figure 3 [illegible]ped into the trash). Figure 2 show[illegible] Figure 4 [illegible] the limited dump Industrial combined industrial and residential Residential [illegible]eams. The total weight of the combined solid waste for 1996 was 4.5 million pounds of waste. Industrial solid waste makes up 60% or 2.7 million pounds of that, and the industrial solid waste distribution by category is shown in Figure 3. Residential solid waste makes up 40% or 1.8 million pounds of the solid waste stream. Figure 4 shows its component distribution.

RECYCLING IS STILL THE ONE
(Continued)

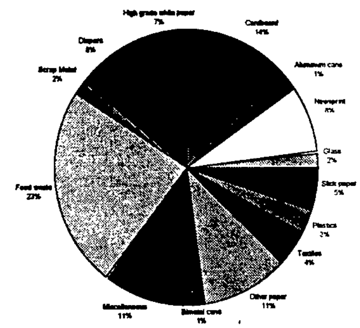
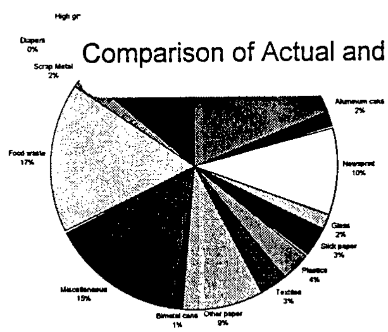
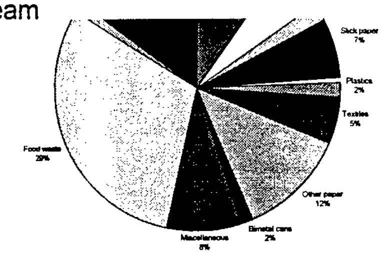


Figure 5
Comparison of Actual and Expected Percentages by Weight of the Combined Solid Waste Stream

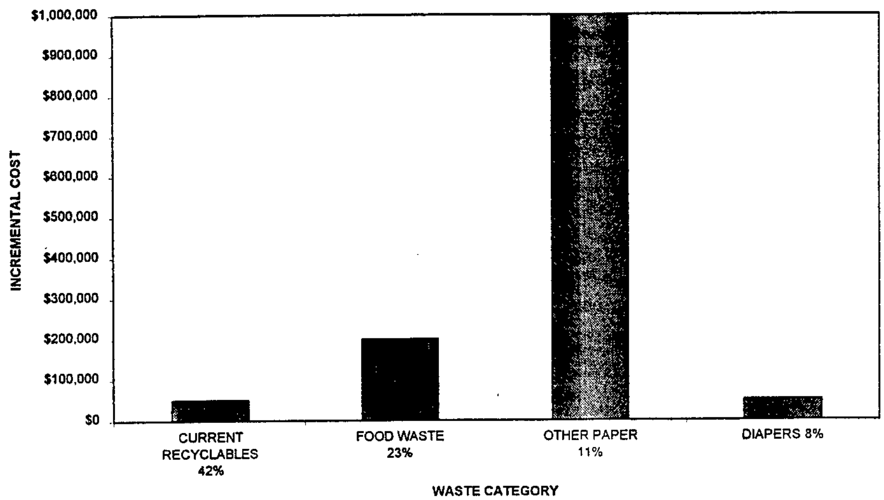




Following the solid waste characterization, a projection of what the recycled components should look like was performed. The "Expected" line in Figure 5 shows what the projected volume by weight of recyclables and other waste components should look like, based on the 31% reduction achieved to date. In other words, the data from the 1992 baseline were normalized and assumed that all reductions came from recycling. Then the data were compared to what was actually found. This comparison is shown on Figure 5. Some recyclables percentages had gone up, such as cardboard, newsprint, and office paper. The good news: Composting activities instituted almost a year previously, in September 1996, at F.E. Warren had captured 99 percent or more of the compostable materials, such as grass clippings, wood, and horse manure (it was a cavalry fort once - the legacy lives on!).

RECYCLING IS STILL THE ONE (Continued)

FIGURE 6
INCREMENTAL COST OF ADDING REDUCTION PROGRAMS BY CATEGORY



Recommendations to decrease SW disposal to meet the 50-percent reduction goal are to continue and improve the current recycling and composting efforts. Parsons ES recommended making recycling more convenient in industrial/commercial and residential areas, and provide more education to Base personnel to capture an additional 75 percent of the recyclable materials now found in the SW stream. Also, operation of the composting facility should continue because it has reduced the amount of yard waste and wood waste to negligible amounts.

The Results: Since the time of this study, F.E. Warren AFB has implemented numerous recycling communication programs, including presentations to the environmental leadership council, creating a web page, publishing reminders in the base newspaper, and distributing recycling bins and bags throughout the base. By rejuvenating the recycling program, F.E. Warren AFB will achieve its solid waste reduction goals.

WHAT IF WE COULD PURIFY AND REUSE OUR WASTE AIRCRAFT HYDRAULIC FLUID?

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INTRODUCTION

The United States Air Force (USAF) spends approximately $30 million per year in the disposal and replacement of used hydraulic fluid. This estimate is based on Tyndall AFB consumption and disposal costs times the number of worldwide Air Force bases with flying missions. Most of this money could be saved if the hydraulic fluid were purified and reused. The Air Force Research Laboratory, Materials and Manufacturing Directorate, Airbase and Environmental Technology Division (AFRL/MLQ), Tyndall AFB, Florida, is sponsoring a project that will enable the Air Force to realize these savings.

Routine USAF aircraft operations generate large quantities of waste hydraulic fluid each year. Through regular use, accumulation of particulate matter and water requires the disposal of the fluid. The Air Force generated a need to evaluate economical equipment and/or processes that would allow the USAF to reuse the contaminated hydraulic fluid (USAF Environmental, Safety, and Occupational Health Need 95-530, Recycling and Verification of Hydraulic Fluid for Reuse). In response, AFRL/MLQ began a hydraulic fluid purification project.

Researchers chose to evaluate a portable hydraulic fluid purifier manufactured by Pall Aeropower Corporation. The Pall purification equipment was selected because it uses a vacuum dehydration, spinning disc process to remove water, air, and volatile organic solvents. It does not use desiccants, heat distillation, or high vacuum that could break down the properties of the base oil. It also incorporates a filtration system to remove particulate matter.

Initial testing revealed the PALL Purifier did not cause any adverse effects on the hydraulic fluid. However, continued testing was needed to evaluate the impact of using purified fluid in aircraft hydraulic pumps. The following text provides information on the testing to date.

INITIAL EVALUATION

In 1995, AFRL/MLQ evaluated the Pall purifier at Tyndall AFB, in an environmentally controlled facility. New hydraulic fluids from Velsicol Chemical Corporation, Castrol Specialty Products Division, and Royal Lubricants, and used hydraulic fluid from Moody AFB, Eglin AFB,

and Dover AFB were evaluated. Each of the new hydraulic fluids was deliberately contaminated with measured amounts of deionized water (1200 ppm) and one gram of AC fine test dust (particulate) at hourly intervals. The Pall purifier was operated for a total of 18.5 hours, for each of the six hydraulic fluids evaluated. Three hydraulic fluid samples were collected from each of the fluids which included: unpurified (baseline), after 8 hours, and after 18.5 hours. The fluid samples were analyzed for degradation at the Materials Engineering Branch (MLSE) of AFRL, Wright-Patterson AFB, OH, in accordance with Military Specification MIL-H-83282C. The fluid was analyzed for viscosity, acid number, rubber swell, water content, lubricity (four-ball wear), evaporation, and oxidation-corrosion. The initial evaluation indicated that the Pall purifier did not degrade the fluids processed.

Based on these encouraging results, AFRL/MLSE recommended that wear testing be accomplished on aircraft hydraulic fluid pumps to determine the impact of fluid purification on pump life/performance. The F-16 emergency power unit (EPU) pump and the main hydraulic fluid pump were selected for these tests because they are common aircraft piston pumps and could be mounted on the test equipment. The Nonstructural Materials Branch (MLBT) of AFRL at Wright-Patterson AFB, OH was tasked to accomplish the tests.

PUMP WEAR TEST #1

The first pump wear test, sponsored by the B-2 Program Office, compared pump wear between two F-16 EPU pumps, operated under load, with both purified and unpurified MIL-H-5606F hydraulic fluid. The two pumps were operated for 1500 hours, each at 3000 psig, with flow rates cycled between 12 gpm and 3 gpm every minute. Each pump was then disassembled and inspected for wear. During the tests, fluid samples were extracted and evaluated for viscosity, water content, lubricity, foaming, metal content, and particle count. At the conclusion of the tests, there was no apparent difference in pump performance and no significant difference between fluid properties, with either purified or unpurified fluid. However, it was noted that there was an equal viscosity change in both the purified and unpurified fluids, which was attributed to the behavior of MIL-H-5606F hydraulic fluid and not the purification process. Again, the results encouraged further testing, this time with MIL-H-83282C hydraulic fluid.

PUMP WEAR TEST #2

The second pump wear test (in progress) is sponsored by the Ogden Air Logistics Center. The objective is to compare pump wear between aircraft pumps, operated under load, with both purified and unpurified MIL-H-83282C hydraulic fluid. However, each fluid will be intentionally contaminated with measured amounts (300 ppm) of distilled water. The two F-16 main hydraulic pumps will be operated for 2000 hours each, at 3100 psig, with flow rates cycled between 28 gpm and 6 gpm every minute. During the tests, fluid samples will be extracted and evaluated for viscosity, water content, lubricity, foaming, metal content, and particle count. Each pump will be disassembled and inspected for wear after 1000 hours and at test termination or 2000 hours, whichever comes first. The first phase of this test using new hydraulic fluid began 4 Feb 98 and was terminated after 1262 hours because a temperature spike in the case drain flow caused an automatic shutdown of the equipment. Pump teardown revealed spalling on the inner race of the roller bearing and the rollers. Excessive wear was also observed on the outer diameter of the cylinder block. Preparations for the second phase of this test are underway using purified hydraulic fluid. The estimated completion date is

December 1998.

OPERATIONAL UTILITY EVALUATION

Headquarters Air Mobility Command (HQ AMC) is currently conducting an operational utility evaluation at McChord AFB, WA on a purifier provided by Pall Aeropower Corporation. This purifier incorporates a state-of-the-art water sensor that automatically shuts off the equipment after a preset level of cleanliness has been reached. HQ AMC plans to determine if the purifier is capable of sufficiently cleaning hydraulic fluid without degrading fluid characteristics and determine if the purifier is logistically supportable. This will be accomplished by purifying new MIL-H-5606, MIL-H-83282, and MIL-H-87257 that has been contaminated with measured amounts of AC fine test dust, deionized water, and PD-680 (solvent). They will also validate procedures to connect the Pall unit to a portable hydraulic test stand, an in-shop hydraulic test stand, and C-141 aircraft hydraulic systems. The estimated completion date is September 1998.

CONCLUSION

It is widely recognized that water and particulate contamination can degrade critical physical properties of hydraulic fluid, impair pump performance, and cause premature failure of the pump. By removing the water and particulates through filtration and purification, users can reuse the hydraulic fluid. The results of the initial evaluation and Pump Wear Test #1 should encourage consumers of large quantities of hydraulic fluid to consider purifying contaminated hydraulic fluid for reuse instead of immediate disposal. **Note:** Hydraulic fluid contaminated with other oils or fuel cannot be purified and reused through this process because it will not separate them.

Commands and Air Logistics Centers wanting to save money could benefit by extending the service life of hydraulic fluid without degrading the fluid's working properties. The average Air Force base can expect to invest less than $50K to reap full benefits of this process, which can be expected to reduce waste hydraulic fluid by 75 percent. The estimated annual Air Force savings of $30 million from use of this process can be multiplied several times, if the process is extended to the Department of Defense and the private sector. This is a truly transferable technology.

It should be noted that the U.S. Army has approved the use of purified MIL-H-46170 and MIL-H-6083 hydraulic fluid in their ground systems. For further information contact Mr. Ralph B. Mowery, AMSTA-TR-D/210, U.S. Army Tank Automotive & Armaments Command, Warren, MI 48937-5000. His telephone number is (810) 574-4220.

The AFRL/MLQ points of contact are Captain Gus M. Fadel, Tyndall AFB, Florida, DSN 523-6462 or (850) 283-6462, or Mr. Edward B. Seaman, BDM International, DSN 523-6290 or (850) 283-6290.

HSMS Implementation at the Detroit Arsenal—Lessons Learned

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Mission and Vision:

U.S. Army Tank-Automotive and Armaments Command (TACOM) is a Major Subordinate Command to the U.S. Army Materiel Command and is the Army's Headquarters for mobility and firepower.

Mission:

To support Army readiness, TACOM's mission is to research, develop, field and support mobility and armament systems through their total life cycle. This includes all combat and tactical vehicles, trailers, construction equipment, material handling equipment, tactical bridges, fuel and water distribution equipment, sets, kits, and outfits, shop equipment, chemical defense equipment, howitzers, large caliber guns, mortars, rifles, machine guns, ammunitions, aircraft armaments, demolitions and explosives, rail, watercraft petroleum and lubrication equipment.

TACOM is "Committed to Excellence" in the total-force endeavors of taking America's Army into the 21st Century. We ensure the Army is a precisely equipped strategic force, capable of power projection and decisive victory.

Vision:

To make the technology and sustainment systems work for soldiers through the seamless integration of science and technology, research and development, acquisition, logistics sustainment and soldier readiness. Also, to create a business environment at TACOM where every associate understands the requirement to control costs and manages from the customer perspective and understands his or her inherent responsibility to do so.

TACOM-Warren Background

The Detroit Arsenal is an Army Materiel Command (AMC) installation located in Warren, Michigan, just a few miles north of Detroit. By Army standards, the Detroit Arsenal is small, consisting of 25 buildings/building complexes. The primary activity at the Detroit Arsenal is the Tank-Automotive and Armaments Command (TACOM) which carries out an industrial production and R&D mission. TACOM-Warren, home of

TACOM headquarters, includes nine major business centers and other organizations: Tank-automotive, Research, Development, and Engineering Center (TARDEC); Integrated Materiel Management Center (IMMC); Resources Management Center; Program Management Tank Automotive Weapon Systems; Acquisition Center, Program Management Light Armored Vehicles (PM-LAV), and Project Manager Tank-Automotive Weapon Systems (PM- TAWS).

An Idea with Merit

The implementation of an automated tracking and management system (HSMS) to control the "life cycle management" of all hazardous materials used at the installation met with some reluctance. One of the most frequently encountered barriers was personnel's resistance to change. They have experienced the shortcomings of the Automated Material Acquisition System (AMAS) and the tendency was to find the path of least resistance to accomplish their mission. Taking the approach of personnel involvement and system knowledge helped to gain their confidence in the HSMS program and what it could do to enhance their respective missions. The idea of a computer-friendly interface with the HMCC, and using the familiar tools already available, reduced the learning curve for material procurement, issue, use and disposal. A biweekly newsletter was provided to each customer during the implementation process informing the individuals of the implementation progression, system updates, system interaction and exchange of ideas with the customer and the implementation team. The interaction between the customer and the HMCC allowed the transition to be timely and customer oriented. The customers realized a greater benefit to the program than the control and management aspect, they no longer were required to prepare documentation to purchase their materials, go pick up their materials and prepare disposal documentation for waste materials. The system did this tedious requirement for them, so that they could perform their respective mission more professionally and in a timely manner.

Implementation History:

The Detroit Arsenal wasn't scheduled to implement the mandated DoD Hazardous Substance Management System (HSMS) until FY02. Knowing this to be the implementation schedule, and the installation's receipt of a notice of finding deficiency involving the tracking and management of hazardous materials, we elected to find a migratory system that could be implemented. The DM-HMMS program is what was chosen after researching various off the shelf programs to attain our goal of a comprehensive system that could satisfy our requirements. After a technical site visit by NCI Information Systems Inc., a package was selected based on functionality, flexibility and cost. With the size of our installation and the support of our commanding general, the Detroit Arsenal decided to implement a project that would track, control and manage all hazardous materials used on our installation. The decision to implement a fully functional program would serve as a model for other installations under the jurisdiction of TACOM.

Communication avenues with AMC were intensified to find an opening that would allow the Detroit Arsenal to implement the Hazardous Substance Management System (HSMS) instead of a migratory system. Lake City Army Ammunition Plant was scheduled to implement the HSMS program in FY97 however, elected to wait on their implementation to a later date. Knowing this to be true, the Detroit Arsenal aggressively attempted to acquire this vacancy. The advanced preparation and dedication of our work group enabled the Detroit Arsenal to be selected for this vacancy.

The Detroit Arsenal established a HSMS Implementation Work Group (Green Team) comprised of representatives from the Safety Office, Base Operations Contractor, Environmental Office, TARDEC, and the Directorate of Installations and Services. The first order of business for the team was to formulate our charter and have it approved by our installation manager. Next was to establish our goals and business practices that would be instrumental in the success of the program. The goals that the Detroit Arsenal established for implementation of a tracking and management system were to:

- provide a tool for facility personnel to help in the management of hazardous materials,
- provide a mechanism to access inventory information,
- increase accuracy of regulatory reports,
- reduce redundancy and required inventory,
- reduce labor required for regulatory reporting and inventory management,
- establish a centralized facility to manage hazardous materials.

In preparation of the HSMS program, our team began an extensive amnesty collection and turn in of excess materials throughout the installation. The turn in of excess materials from the installation encompassed a five-month period. The result was fruitful, with approximately 4,500 gallons of usable materials, and an additional 33,000 gallons of usable fuel was collected. Our team found various agencies in need of our excess materials and prepared documentation to ship these materials free of charge. This effort resulted in a cost savings/avoidance of approximately $215,000 for the Detroit Arsenal.

The initial site visit briefing for the Detroit Arsenal occurred on 28 July 97. At this briefing the guidelines were established to implement Full Operational Capability (FOC) configuration. This method of implementation is totally different from the norm. The Detroit Arsenal thought because of our size and our commitment to our goals, we would include the entire installation in the program all at once, as opposed to segmenting various organizations one at a time into the program. The Hazardous Substance Management System Work Group (HSMSWG) provided guidance during the implementation efforts. Following completion of the implementation efforts, the Installation Hazardous Materials Committee (IHMC) was established and replaced the HSMSWG to provide installation-wide management and control of Hazardous Material and Hazardous Waste generation. The Detroit Arsenal components of the IHMC are defined in the Detroit Arsenal Charter. The Detroit Arsenal is a contractor operated Department of Public Works installation, which presents a challenging implementation process.

Training and an understanding of the automated system and its functionality became increasingly important for a well-organized implementation process. A trip to Ft Campbell, KY and White Sands Missile Range, NM, was conducted to review their HSMS programs, and gain insight on program operations. Additionally, HSMS "101" training was provided by the Army Environmental Center. This training offered a well rounded module on HSMS, and provided an understanding of centralized hazardous material control, storage, issue, reuse and recycling.

Purpose of the HMCC

The basic premise of the "HAZMART" concept is the centralized control of hazardous material entering the installation. The implementation of the Hazardous Material Control Center (HMCC) using the "HAZMART" concept at the Detroit Arsenal will be key to reducing the amount and types of HM brought on post. A closely related effect of implementing the concept is the reduction of hazardous waste. The HMCC will be the issue point where all HM is procured, received, stored, and issued. The HMCC will also pick up waste materials, partial containers of materials and process these materials accordingly. The centralized facility meets the needs of our customers by being customer friendly and customer oriented.
HMCC operations will incorporate the following:

- shelf-life management of HM;
- single point control of all HM;
- turn-in and reuse of HM;
- turn-in and recycling of spent HM and/or HW;
- re-stocking delivery service for HM/HW provided by HMCC;
- one-week shop stock at user locations; and
- two-week contingency stocks maintained at the HMCC.

There are numerous benefits to be derived from the establishment of the "HAZMART" concept. They include:

- reducing duplicate stockage and stockpiling of HM;
- controlling and reducing the quantity and types of products locally procured;
- reducing fines and penalties as a result of Notice of Violations (NOVs);
- increasing Pollution Prevention (P2) opportunities through material substitution;
- decreasing the potential for spills and releases;
- extending shelf-life;
- increasing the visibility and control of HM entering the installation;
- tracking from "cradle-to-grave," ("life cycle management")
- reducing HW disposal costs;
- reducing acquisition cost through re-use; and
- reducing liability and potential personnel health and safety risks.

Check and Balance Program

Unexpected and substantial changes in the HMCC's procurement procedures created significant obstacles during the implementation process. The Detroit Arsenal is

transitioning away from credit card purchases and use of the Army Material Command Installation Supply System (AMCISS) to procure hazardous materials, towards a "Just-In-Time" procurement philosophy. Implementation of these changes were accomplished with two goals in mind: first, to reduce labor and cost for purchase of materials; and second, to reduce the quantities of materials stored on-site. These goals were accomplished through "just-in-time" supply contracts with local vendors. The HMCC personnel are the only personnel authorized to procure hazardous materials with a credit card, unless an "emergency" procurement necessitates otherwise.
The "emergency" procurement of materials must be annotated with the HMCC on the first business day after the emergency purchase for accountability and tracking purposes. The only way to monitor if our customers are reporting all of the hazardous materials they purchased throughout the year with the current credit card procedures is to conduct periodic audits of credit cards and storage areas.

Lessons Learned:

The most valuable lessons learned throughout the implementation process can and should be applied to any federal facility implementing an automated hazardous material tracking and management system. The lessons learned at the Detroit Arsenal were:

- **Business Practices.** Existing practices can be changed, develop policies and procedures to be applied facility-wide to improve the stature of the installation.
- **Listen to the End Users.** The personnel who will actually be using the HSMS on a daily basis can provide valuable feedback on how the system works in the "real world".
- **Be Flexible.** The Detroit Arsenal found being flexible in the manner it addressed the implementation issues and involving end users in the process improved the implementation.
- **Continuous Improvement Process.** Implementation and maintenance of HSMS requires a continuous improvement process, as we progress to the Environmental Inventory Management (EIM). The world we live in today changes rapidly. HSMS will need to cope with these changes as rapidly as possible.
- **Implementation Contractor.** Work closely with your respective contractor; listen to their suggestions even if they deviate from your original methodology. The implementation of HSMS can be a well-orchestrated transition if everyone concerned has an open mind and is willing to change for the well being of the program.
- **Stay Focused.** Implementing an automated tracking and management system is very wearing and time consuming on both personnel implementing the system and customers who will be using the program. Those who are focused, flexible and willing to change create good things.

Conclusion:

The Detroit Arsenal began its implementation of an automated hazardous material tracking and management system with six major goals. The main focus of these goals

was to provide a tool to the HMCC personnel to assist them in the management of hazardous materials, reduce labor cost for both inventory management, documentation of hazardous waste generation and provide a computer friendly easy access to inventory information. To successfully implement a hazardous material tracking system, the HMCC required a system that would be a stand alone program, allow access by numerous customers, provide a user friendly interface, and streamline the procurement and management requirements, and automate regulatory reporting demands.

The Detroit Arsenal successfully overcame all obstacles associated with the implementation process, to include pushing the system to its breaking point by using the system as an accounting system. The HSMS is not intended to be an accounting program, but rather a tracking, control and management tool. However, with the expertise of our data base administrator and our system administrator, along with the assistance of our implementation contractor (Dynamac Corporation), we were able to track cost for each business center and report this information to the program control manager for budgeting, to accomplish a check and balance. Once, this function has reliable history and accountability, the Detroit Arsenal will submit a System Change Request (SCR) to be incorporated for all HSMS users.

Throughout the ten-month implementation process that was finalized and operational on 15 May 98 the established business practices at the Detroit Arsenal became more visible as working document that enhanced our vision and mission. We became more aware of how the installation could save precious revenue and reduce our liability concerning health and safety issues. The benefits of the program will be realized over a period of time using the system and making necessary system changes.

Session XV
Compliance Through P² Initiatives

Session Chairpersons:

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Beyond Compliance: Use of P2 and Process Change to Achieve Facility Deregulation

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Introduction

Pollution prevention (P2) has evolved over the past decade. Ten years ago most facility managers pursued P2 initiatives simply to reduce the quantities of wastes produced. As toxic release inventory (TRI) numbers became widely available and interpreted by the public, additional pressure was brought to bear upon facilities to "reduce their numbers." As P2 efforts continued, a new significant benefit began to emerge, one that is now being realized as a most potent driving force for even more P2 initiatives. That benefit is deregulation, or removal of the facility from the regulatory arena, by using P2 and process change.

The idea of regulatory relief stemming from P2 efforts is supported through examination of individual environmental media. Eliminating use of toxic chemicals eliminates requirements for employee exposure monitoring under occupational safety and health laws. Eliminating water and air emissions eliminates the need for environmental construction and discharge permits. Eliminating generation of solid and hazardous wastes eliminates regulatory record keeping, regulatory enforcement inspections, and legal liability for waste handling and disposal.

This paper demonstrates the approach to achieving facility or installation deregulation through extensive use of pollution prevention techniques and process change. The approach is developed from observation of private sector facilities; parallels are drawn to federal facilities as well. The paper presents data from several industrial case studies in which facilities achieved significant or total deregulation by a combination of P2, process change, and reengineering.

Deregulation of a Process through Administrative Changes

In the early 1990s an initiative was begun to prevent accidental releases of certain chemicals stored and used in "stationary sources" such as manufacturing operations. When Congress amended the Clean Air Act in 1990, legislators included accidental release prevention requirements; following the Congressional mandate EPA promulgated the Risk Management Plan (RMP) rule. This rule requires an analysis of potential release mechanisms and their effects on "public receptors". It also requires that a program be put into place to prevent accidental releases and to mitigate the effects of any releases that do occur. The deadline date for stationary sources that are "covered" by the rule to have a program in place and electronically filed is June 21, 1999, and plans must be reviewed and updated every five years.

The RMP rule sets specific definitions for determining whether a process is covered under the rule. For example, the rule states that a stationary source that uses, processes, or stores more than a threshold quantity of a regulated substance in a process at one time is covered.

Stationary sources include those sources present at federal installations and private sector sites, including manufacturing and processing areas , storage areas, water and wastewater treatment facilities, and others. There is a list of regulated substances (some mandated by Congress, others listed by EPA) that are of concern as to the potential for their release. The substances on the list are classified as toxics (gases or liquids), flammables, and explosives. Common chemicals which are regulated substances include propane, chlorine, and ammonia. The rule establishes a "threshold quantity" of each regulated substance, above which quantity the rule applies. A process includes actual process units as well as associated vessels and piping. The idea is that, should an accidental release occur, the associated piping and vessels are subject to having their contents released. Many federal installations have several "covered processes" on the installation; for those that do, a single RMP document that addresses all of the covered processes is required.

The judicious application of P2 and administrative controls can minimize an installation's "coverage" in the RMP program. For example, a change from a regulated substance as a raw material to an alternate substance that is not regulated will remove a process from coverage. As another example, if an installation has a process with storage vessels that can contain such quantities of a regulated substance that the process would be covered, installation personnel may be able to apply administrative controls to the process. Administrative controls ensure that the amount stored and in process at any one time is always less than the threshold quantity. For gases, administrative controls may include pressure regulation; for liquids, level controls. In both cases, the automatic controls serve to maintain the stored quantity of the regulated substance below threshold quantities. In many cases, a simple written policy appended to the installation environmental management (information) system (EMS or EMIS) suffices.

The initial cost savings (not including the five-year updates) attributable to elimination of a process from RMP requirements can vary widely depending upon the complexity of the process and modeling requirements. Examples observed to date range from savings of approximately $2,000 for a simple propane tank to more than $20,000 for a complex process involving chemical reactors.

Deregulation through a Change in Paint Process

Frigidaire Home Products, a subsidiary of AB Electrolux—a large maker of household appliances—employs 1,100 people in a refrigerator manufacturing plant at Anderson, South Carolina. Until recently appliances and components produced at the facility were painted using traditional solvent-based coatings.

After considerable research and testing, the company converted to a powder-coating system for painting the refrigerator and freezer doors. Frigidaire invested $1.5 million in this effort and, as a result, the facility completely eliminated all wet paints and related solvents, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs) from the painting process, thereby eliminating all hazardous wastes.

The deregulation benefits to the facility are in two general areas:

- The facility has changed from "large-quantity generator" status to a "conditionally exempt small-quantity generator."
- The facility avoided a costly Title V air permit application and all of the regulatory burdens and related impediments; the facility holds "conditionally exempt" status.

A substantial amount of the $1.5 million cost will be recovered in the first year alone, representing a payback period of one and one-third years. The accompanying direct savings come from an array of sources: reduced service calls, lower raw-material costs, nonexistent waste-disposal costs, fewer defective parts, and lower energy and operating costs.

The powder-paint project has had a profound impact in several ways. In the area of hazardous waste, as stated earlier, the project has enabled Frigidaire to become a conditionally exempt generator (previously a large-quantity generator) as the company no longer generates any hazardous waste requiring disposal. Even the nonhazardous wastes, such as the paint filters that were normally destined for a secured landfill, are no longer present. In addition, the wastewater treatment process benefited from the process change through the elimination of the risk of solvent spills into the sewer. The plant is also successful in complying with all the requirements of the sewer-use permit, and it has vowed to continue its waste minimization efforts by exploring a "zero discharge" status in the plant's process effluent.

The "indirect" or regulatory relief cost impacts are significant. Estimates made by plant environmental staff are that the change from large to small quantity generator of hazardous waste saves the facility approximately $10,000 per year in monitoring, paperwork, and related costs. Similarly, the change to a conditional major in the air program has saved an additional $40,000 in permitting and monitoring costs.

Deregulation of a Facility through P2 and Reengineering

MEMC Electronic Materials, Inc., manufactures polished and epitaxial silicon wafers [epitaxial or "epi" wafers are a value-added product where the surface of a polished wafer receives a thin layer of ultra-pure silicon]. Silicon wafers are the substrate, or base, on which microelectronic circuits (microchips) are built. The primary product of the MEMC manufacturing facility in Spartanburg, South Carolina, is the 150-millimeter diameter polished silicon wafer. Process operations at the Spartanburg plant involve silicon crystal growth and wafering.

MEMC's business is characterized by short product life cycles, stringent product quality specifications, and continuous investing in new manufacturing technology to keep pace with customer requirements. In a dynamic environment like this, it is realized that capital spent on end-of-pipe pollution controls to comply with environmental laws represents capital not available for improving product quality or expanding manufacturing capacity. In 1989 MEMC realized that the traditional "tail pipe" approach to managing environmental regulations was not economically sustainable.

The company established the following environmental goals and deadlines in 1989:

- Reduce hazardous air emissions by 80 percent by year-end 1994.
- Eliminate the use of ozone-depleting chemicals (ODCs) by year-end 1995.
- Reduce the generation of priority waste by 50 percent by year-end 1996. (*Priority waste* includes hazardous waste and nonhazardous recyclable materials that are landfilled.)

The base year for these goals was 1988, and the 1989 goals reflect environmental issues that had the greatest impact on MEMC operations at that time. Where possible, the goals were to be

achieved by waste elimination rather than with end-of-pipe pollution controls.

As discussed further below, MEMC achieved success in meeting the goals set in 1989, and set an additional series of goals to be met by the end of 1997:

- Reduce the remaining hazardous waste generated by 70 percent (1991 base year);
- Reduce the solid waste landfilled by 50 percent (1991 base year); and
- Reduce the emissions of criteria air pollutants by 25 percent (1993 base year).

In 1994, the plant underwent "re-engineering." A number of projects selected for implementation included waste elimination and the improvements in resource efficiency.

The major projects undertaken by the facility staff related to P2 and deregulation from 1988 through 1997 included the following:

- Reduction and later elimination of chromium-based etchant solutions.
- Reduction and later elimination of all use of chlorinated organic solvents, including ozone-depleting substances.
- Solid waste recycling program.
- Boiler fuel conversion from fuel oil to natural gas.
- Package redesign for reuse.
- Water reuse program.

Cumulative waste reduction and regulatory relief achieved by pollution prevention projects at the plant are discussed below.

Hazardous Waste. The solvent-use elimination project was completed in 1993. No hazardous waste solvents were generated by manufacturing operations in 1994, 1995, and 1996. The chrome-use elimination project was completed in 1995. During 1996, no RCRA-regulated hazardous wastes were generated by manufacturing operations at the plant. In 1988, the plant had interim status as a RCRA Treatment, Storage, and Disposal (TSD) facility for greater-than-ninety-day storage of hazardous waste. At that time, MEMC felt this was the most practical way to manage the large quantity of hazardous waste generated by manufacturing operations. In 1990, the facility received a final RCRA Part B permit for container storage of hazardous waste. The final permit was forty pages with more than 200 specific conditions. The experience of the RCRA permit demonstrated the large administrative effort necessary to obtain a major environmental permit and to maintain compliance with permit conditions.

In 1991, South Carolina imposed new site-location and risk-assessment standards for RCRA TSD facilities. The new standards were retroactive and would require the plant to upgrade its two RCRA-permitted hazardous waste storage pads. As a result, MEMC determined TSD facility status was no longer economically justifiable. In August 1991, the plant ended greater-than-ninety-day storage of hazardous waste and operation as a RCRA TSD facility. This change was possible due to success of the chrome- and solvent-use reduction projects completed in 1990.

By 1994, MEMC Spartanburg reduced manufacturing generation of hazardous waste by more than 96 percent compared to 1988. In March 1994, the company officially closed its two RCRA-permitted hazardous waste storage pads and was released from financial assurance requirements for closure and post-closure care. The chrome-use elimination project completed in 1995 ended

all manufacturing generation of hazardous waste at MEMC Spartanburg. The plant became a small-quantity (less than 1,000 kg per month) hazardous waste generator. In February 1996, MEMC was officially released from all TSD facility portions of its RCRA Part B permit.

The experience of obtaining and then eliminating the RCRA Part B permit convinced MEMC that major environmental permits should be avoided wherever possible. The administrative time and cost to eliminate TSD portions of the RCRA permit were even more than the effort initially required to obtain this permit.

Air Emissions. Chlorinated solvents and associated air emissions and hazardous waste generation were eliminated from the plant in 1993. The small quantity of solvent used in manufacturing after 1993 was isopropyl alcohol (IPA). Boiler fuel conversion and elimination of acetic acid epoxy removal reduced criteria pollutant air emissions by 77.1 percent between 1993 and 1997. This accomplishment far exceeded the 1994 MEMC goal for a 25-percent reduction by year-end 1997.

The 1990 Clean Air Act (CAA) Amendments substantially changed industry management of air emissions. Prior to the CAA, major air pollution source designation was based on actual annual emissions of criteria air pollutants. The definition of "major source" was the same regardless of location in the United States. Air toxics were not included in the definition of major air emission source. After 1990, major air emission sources were defined by potential-to-emit rather than actual emissions, major source thresholds for criteria pollutants were based on ambient air quality, and air toxics emissions were added to criteria pollutants for major source determination.

Permit application, air quality modeling, and public review requirements for major air emission sources under the 1990 CAA are substantial. In South Carolina, major air emission source permits typically require twelve to eighteen months to obtain. In contrast, minor air emission source permits (regulated by state law) can be processed in sixty to ninety days. The Spartanburg plant was a minor air emission source prior to 1990. The facility managed actual criteria pollutant air emissions to stay below source thresholds.

In 1991, MEMC management realized that the Spartanburg plant would become a major air emission source under the 1990 CAA unless substantial changes were made. It was not acceptable for environmental permitting to delay manufacturing process changes needed to meet customer requirements. Such delays were likely if the facility was required to file for a Title V air quality permit.

The solvent-use elimination project completed in 1993 avoided major source designation for air toxics by eliminating chlorinated solvent air emissions. Boiler fuel conversion, completed in 1995, reduced the plant's potential-to-emit SO_x and NO_x below major source thresholds. These changes allowed MEMC Spartanburg to remain a "minor" air emission source regulated under state and not federal law. Elimination of acetic acid epoxy removal in 1996 further reduced plant VOC air emissions. MEMC Spartanburg submitted its "Conditional Major" (synthetic minor) air quality operating permit application in November 1995. The application provides reserve capacity for manufacturing expansion and process change without triggering major source thresholds under the 1990 CAA.

The experience of preparing for implementation of the 1990 CAA demonstrated that waste elimination can avoid major environmental permits and associated delays for regulatory review.

Solid Waste. Between 1990 and 1996, MEMC reduced plant trash landfilled by more than 64 percent. This exceeds the 30 percent landfilled waste reduction goal in the 1991 South Carolina Solid Waste Policy and Management Act. The landfilled waste reduction since 1991 is more than 50 percent, which exceeded the 1994 MEMC environmental goal. Between 1993 and 1996, the plant increased the recycling rate by weight from 44 percent to 59 percent.

MEMC Spartanburg cannot operate without access to local landfills for nonhazardous solid waste disposal. Solid waste recycling efforts helped insulate the plant from landfill price increases and restrictions resulting from implementation of the 1991 Solid Waste Act. For example, it is now illegal in South Carolina to landfill wooden pallets unless they are shredded. MEMC had a program for the in-place recycling of wooden pallets before the landfilled "pallet ban" went into effect.

Occupational Safety and Health. Waste elimination also brings regulatory relief under occupational safety and health laws. The use of toxic chemicals in the workplace is strictly regulated. These rules specify permissible exposure limits (PELs) and require monitoring of industrial hygiene to verify that legal maximums are never exceeded. The rules may also require process ventilation, engineering controls, personnel protective equipment (PPE), hazard communication, special employee training, medical monitoring, and long-term retention of medical records and industrial hygiene sample results. The solvent-use elimination project completed in 1993 eliminated legally required engineering and administrative controls for chlorinated solvents. The chrome-use elimination project completed in 1995 eliminated similar requirements for hexavalent chromium.

Conclusion

This paper has shown how several facilities have used pollution prevention principles to gain an advantage that was unrecognized by many until recently. These facilities have shown that process changes for the elimination of waste and the improvement of resource efficiency can help avoid environmental permits and reduce the burden of compliance with environmental laws.

Regulatory relief gained from pollution prevention projects can provide reserve capacity for manufacturing expansion without triggering new, major environmental permit requirements. This flexibility for quick implementation of manufacturing process change is an important competitive advantage. It enables any industrial facility or federal installation to respond rapidly to changes in market demand or mission readiness.

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IMPLEMENTATION OF COMPLIANCE THROUGH P2 IN AFMC

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BACKGROUND

AFMC is unique among the Air Force Major Commands because of its weapon systems acquisition and sustainment mission. These industrial type activities present diverse and complex Environmental, Safety, and Occupational Health (ESOH) challenges. The command uses most of the Air Force's hazardous materials and has nearly 80% of all regulatory permits issued to the Air Force. The EPA's 1994 Toxic Release Inventory (TRI) showed that AFMC installations or plants accounted for six of the top ten DoD facilities in terms of quantities of toxic materials releases. Since that time, AFMC has attained the Air Force's 1999 goal of 50% reduction in toxic releases, due in part to the large investment in pollution prevention (P2) equipment and technology. In this manner, AFMC has addressed compliance with P2 solutions for several years, and the reduction in pollution should result in a corresponding decrease in environmental compliance burden. Even so, AFMC's planned outyear budget for compliance activities (monitoring, reporting, permits, etc.) is projected to remain relatively flat through FY03. The Federal budgetary climate is forcing a change in this situation.

DRIVERS FOR CHANGE

Concern has been growing in Congress over continued P2 investment with little or no decrease in the compliance burden. The expectation was that compliance costs would be reduced as P2 investments address compliance requirements and the resulting savings could then go toward mission support. In response to these concerns, the Air Force is requiring a 20% shift in compliance funds to P2 efforts by FY03. This does not equate to an increase in total environmental funding, however, the AFMC P2 budget will increase from 18% of environmental quality funding in FY96 to 38% in FY03.

The Air Force is committed to using P2 solutions as a cost-effective means of addressing compliance requirements. Over the past several years, AFMC's P2 investments and the

interaction of their P2 and EC efforts have curbed the growth of compliance requirements (e.g., addressing outyear NESHAP requirements with solvent reduction initiatives). With this experience, the command was able to assist Air Staff in developing policies for addressing compliance with P2 solutions, and helped rewrite AFI 32-7080. USAF/ILEV issued guidance in August and November of 1997 defining a requirement to reduce compliance burdens by addressing the root causes of environmental problems through implementation of P2 solutions, which is Compliance Through P2 (CTP2).

AFMC'S ACTIONS

Because P2, by definition, reduces solid and hazardous waste/materials by addressing them at or near the beginning of the process pipeline, it consequently reduces the amount of pollution that must be dealt with at the disposal end of the process, so activities that reduce pollution will likely affect compliance activities. However, AFMC's strategy for prioritizing P2 investments prior to FY98 treated potential reduction in compliance burden as a side benefit. Priorities instead were based upon the amount of Toxic Release Inventory (TRI) chemicals, EPA-17 chemicals, or Ozone Depleting Substances (ODSs) that could be eliminated. What counted was that the total aggregate of a chemical be reduced toward meeting the Air Force's 1999 goal, not that the reduction resulted in the elimination of a compliance activity.

AFMC's Environmental Division (HQ AFMC/CEV) will execute \$90.7M of the Air Force Environmental Quality (P2 and compliance) budget in FY98. It has set out to be the Air Force, and possibly the DoD, leader in establishing and operating cost effective P2 programs to enhance mission support. AFMC/CEV has recognized the need to institutionalize CTP2 as a cost-effective way to meet the command's environmental goals. It has progressed towards that goal by: (1) altering P2 investment priorities for FY99 by changing the emphasis from "pounds reduced" to "compliance burden reduced", (2) including "Compliance Sites Addressed" as a business activity and Business Performance Indicator (BPI), (3) modifying the P2 project review process to incorporate review by both P2 and EC functions, and (4) adjusting P2 management activities such as Opportunity Assessments to more directly link P2 with compliance. While maintaining an emphasis on the existing solid and hazardous waste program areas, AFMC is re-engineering the P2 program to help customers reduce their compliance burden and liability.

CTP2 SUCCESSES TO DATE

For the past few years, AFMC has been reaping CTP2 benefits from its traditional waste stream reduction initiatives. A prime example of this is Oklahoma City ALC's investment in Aqueous Pressure Spray Washer Cleaning Systems, used in parts cleaning and degreasing. The spent solution from the parts cleaners can be sent to the wastewater treatment plant instead of having to be disposed as hazardous waste. Use of the spray washers eliminated 220,000 pounds of 1,1,1-trichloroethane, 25,000 pounds of CFC-113 (Freon) degreasers, and 8,000 pounds of PD-680 annually. The new process reduced the amount of waste and materials governed by the Clean Air Act and RCRA, decreased process times, and increased worker safety.

Recently, AFMC has been pursuing innovative CTP2 projects. These efforts link P2 investment directly with a corresponding reduction in compliance burden and ultimately reduce the costs of compliance. The emphasis on cost payback in these investment decisions mirrors the command's move toward a more businesslike approach to how funds are allocated.

1. Arnold AFB invested in a wastewater loopback system which allows reuse of some of its cooling water. This reduced the amount discharged into two ditches, which requires NPDES permits. Reducing the discharge into the ditches reduced the need for monitoring, analysis, sampling, and reporting for both NPDES permits and the high-cost Toxicity Reduction Evaluation (TRE) required by the state of Tennessee for discharges with high biotoxicity.

2. Warner-Robins ALC is investing in a wastewater disinfection process change from chlorine to an ultraviolet system. It will eliminate the requirement for (a) a Risk Management Plan (RMP) for chlorine (an extremely hazardous substance) under Section 112 of Title III of the Clean Air Act of 1990, and (b) a chlorine removal system to keep amount in the discharge below NPDES permit limits. The investment will pay for itself in 3.75 years and after that time will save the Air Force about $20,000 annually.

3. Eglin AFB has initiated recycling of used plastic media blast, fluorescent light tubes, antifreeze, and R-22 refrigerant instead of handling and disposing of them as hazardous waste. Liability associated with their handling and disposal will be reduced, and the payback period is approximately three years.

4. Edwards AFB has derated two of its gas-fired hot water boilers below 5,000,000 BTU/hr, and is proposing to derate four more. This will eliminate the need to maintain permits for those boilers in accordance with the Kern County Air Pollution Control District requirements.

AFMC'S BUSINESS ORIENTATION

AFMC is in the process of transitioning from using a "budget" management system to a "cost" management system. The challenge is to move toward operating like a business in FY98. This initiative reflects the command's commitment to implement SAF/MIQ's proposal to increase productivity by lowering ESOH costs. Under the old system of budget management, funds were justified based upon inputs such as pay, supplies, projects, etc. In activity-based cost management, funds are justified with activity outputs, unit costs and a standard level of service applied consistently across the command.

The Installations and Support (I&S) Business Area is one of eight identified for the command, and Environmental Management is one of four I&S business lines. Environmental Management has four product lines, one being P2. The P2 product is to "help customers reduce compliance burden/liability and maintain previously implemented P2 initiatives". The P2 product line has seven defined activities that support it.

AFMC plans to revise its MAP format in FY99 to have installations list their compliance sites with associated compliance requirements. Under a new format, OAs will be conducted with the goal of reducing compliance burdens, and from these OAs will come the future projects that will reduce the cost of doing business.

CONCLUSION

AFMC's P2 program will continue to meet AF and DoD environmental goals and objectives even during periods of budgetary constraints. But more importantly, the reduction efforts will shift from attempting to eliminate the greatest number of pounds to eliminating those pounds which create the greatest environmental compliance burden. AFMC is a leader at ensuring that cost effective solutions are used to achieve "Compliance Through P2" in the present and future. This proactive approach - along with the fact that P2 makes good business sense - will ensure our environmental programs continue to enhance AFMC mission readiness.

Aerospace NESHAP Compliance through Pollution Prevention-
TRIAD Implementation

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INTRODUCTION

Robins Air Force Base (AFB), home to Warner Robins Air Logistics Center (WR-ALC), is the single largest industrial complex in the state of Georgia. WR-ALC performs heavy repair and maintenance on C-130, C-141, and C-5 transport aircraft, the F-15 fighter, and avionics, electronic warfare, and aerospace ground equipment (AGE). Robins AFB also hosts the 116th Bomb Wing (B-1B), the 93rd Air Control Wing (J-STARS), and the 19th Air Refueling Group (KC-135R). Multiple aircraft-related activities occur all over the installation, and many of these activities require materials and processes regulated by the National Emissions Standard for Hazardous Air Pollutants (NESHAP) for Aerospace Maintenance Facilities. This regulation goes into effect on 1 September 1998, and any operations not in compliance will be halted. Robins AFB has identified three main process areas currently non-compliant with the Aerospace NESHAP: 1) Handwipe Cleaning; 2) Spray Gun Cleaning; and 3) Depaint of F-15 wings and stabilizers.

Clearly, Robins AFB is in immediate need of finding replacement materials and/or processes to bring them in compliance with the Aerospace NESHAP. In addition to regulatory compliance, alternatives must satisfy the requirements of the environmental, safety, and occupational health (ESOH) community and the systems engineers. Successfully attacking each non-compliant process requires a flexible methodology to devise a project budget, a unique development and test plan, and a feasible implementation plan. Robins AFB's needs are being met through the Toxic Release Inventory Alternative Development (TRIAD) project, a total engineering, environmental, safety, and occupational health (E-ESOH) management approach and partnership among systems engineers, the ESOH community, and SAIC.

OBJECTIVES

With regard to the Aerospace NESHAP, the objective of Project TRIAD is to identify and validate NESHAP compliant materials or processes to ensure no mission-critical operations are halted due to non-compliance. Operations currently out of compliance with the Aerospace NESHAP utilize materials such as methyl ethyl ketone (MEK), denatured alcohol, and some paint thinners. It is the goal of Project TRIAD to replace these chemicals when possible and identify compliant processes and/or equipment when it is not. Project TRIAD follows the

replacement process through research and identification, testing and validation, development of implementation plans and technical order (TO) changes, and shop implementation and training.

TECHNICAL APPROACH

Each of the target process areas were addressed in three stages, according to the TRIAD management methodology: 1) Process Evaluation and Alternative Identification, 2) Alternative Testing and Verification, and 3) Alternative Process Implementation.

Hand-Wipe Cleaning

Hand-wipe processes at Robins AFB include pre-paint wipedowns, pre-adhesive cleaning, spot cleaning, and plastic media blast (PMB) residue removal prior to painting. Hand-wipe cleaning processes must meet the requirements of Aerospace NESHAP regulations by 1) using either an aqueous or hydrocarbon-based solvent, 2) using a solvent having a composite vapor pressure of 45 mm HG or less at 20(C, or 3) demonstrating that the volume of hand-wipe solvents used in cleaning operations has been reduced by at least 60 percent from a baseline adjusted for production. These regulations are per 40 CFR 63.744 (b). Though some of the above listed processes are exempt under the Aerospace NESHAP, Robins AFB has targeted them under their hazardous air pollutant (HAP) and toxic release inventory (TRI) reduction programs.

Process Evaluation and Alternative Identification. The first step in developing alternative materials and/or processes is thoroughly evaluating the current operation to determine the process requirements. Hand-wipe processes were evaluated in the C-130, C-141, C-5, and F-15 aircraft directorates and the TI industrial support directorate. Table 1 provides a list of the processes evaluated during the course of this effort.

Table 1

Hand-Wipe Cleaning Processes

Directorate Buildings Solvents Currently in Use Hazardous Constituents Classifications LB 44, 91, Pad 9 Marsol,
MIL-C-38736B, Type I Toluene
Xylene
Ethyl Benzene HAP, TRI
HAP, TRI
HAP, TRI LB 44, 91, Pad 9 Denatured Alcohol Methanol
Toluene HAP, TRI
HAP, TRI LB 50 MEK MEK HAP, TRI LC 54 MEK MEK HAP, TRI LC 125 Marsol,
MIL-C-38736B, Type I Toluene
Xylene
Ethyl Benzene HAP, TRI
HAP, TRI
HAP, TRI LC 125 Denatured Alcohol Methanol
Toluene HAP, TRI
HAP, TRI LF 137B MEK MEK HAP, TRI LJ 47, 81, 82 Marsol,
MIL-C-38736B, Type I Toluene
Xylene
Ethyl Benzene HAP, TRI
HAP, TRI
HAP, TRI LJ 47, 89 Isopropyl Alcohol None NA LJ 81, 82 Denatured Alcohol Methanol
Toluene HAP, TRI

HAP, TRI LJ 81, 82 Ethyl Alcohol None NA LJ 89 MEK MEK HAP, TRI LJ 89 Toluene Toluene HAP, TRI TI 125 Denatured Alcohol Methanol Toluene HAP, TRI

HAP, TRI TI 169, 180, 605, 670 MEK MEK HAP, TRI TI 169 Toluene Toluene HAP, TRI TI 169, 670 Isopropyl Alcohol None NA TI 180 Toluene Toluene HAP, TRI TI 605 Dry Cleaning Solvent Benzene HAP, TRI The process analysis focused on the solvents currently being used, the substrate upon which they were used, the contaminants removed from the substrates, and the paint systems applied to the substrates following hand-wipe cleaning. Common substrates included aluminum, magnesium, steel, titanium, and some composites. The contaminants being removed from the surfaces were typically jet fuel, hydraulic fluids, lubricating oils, PMB residue, and uncured adhesives and sealants. Based on the data gathered regarding the current operation, performance criteria were developed against which alternatives are tested. The performance criteria include regulatory requirements, chemical characteristics, material compatibility, and performance requirements which alternatives must meet for implementation. The performance criteria addresses specific testing that must be performed on each alternative as well as the standards that each must meet.

Based on the process evaluation and subsequent performance criteria, SAIC identified potential alternatives through literature searches, testing review, and networking. SAIC focused on Original Equipment Manufacturers (OEM) and Department of Defense (DoD) maintenance facilities as sources of initial information. These facilities perform operations similar to those at Robins AFB and are under the same requirements to implement alternatives to comply with the Aerospace NESHAP. Included in the investigation were Boeing (California, Washington, and Georgia plants), Lockheed-Martin (Texas and California operations), Northrop Grumman (California, Georgia, and Florida plants), Sacramento ALC, Oklahoma City ALC, and Ogden ALC. A thorough vendor and literature search followed the investigation to form the list shown in Table 2.

Table 2

Hand-Wipe Alternative Cleaners

Product Manufacturer Product Manufacturer Desoclean 110 Courtaulds Aerospace DS-104 Dynamold Solvents, Inc. DS-108 Dynamold Solvents, Inc. MPK Eastman Chemical Company LPS 104F LPS Laboratories, Inc. LPS Super 140 LPS Laboratories, Inc. Pensolv K4HP West Penetone Pensolv R-420 West Penetone PF Degreaser PT Technologies, Inc. Positron Ecolink, Inc. Prepsolv Ecolink, Inc. SD 1291 Brulin & Company, Inc. Skykleen 1000 Aviation Solvent Solutia, Inc. Skykleen 2000 Solutia, Inc. Teksolv EP Inland Technology, Inc. ALK-660 Eldorado Chemical Company, Inc. Armakleen M-AERO-NS Church & Dwight Co., Inc. B&B Re-Gel B&B Tritech, Inc. Calla 800 Zip-Chem Products Cee Bee A-882 McGean-Rohco, Inc. Cee Bee A-883 McGean-Rohco, Inc. DOT 111/113 Delta-Omerga Technologies, Ltd. Penair HD-2 West Penetone Penair HD-3 West Penetone Penair HD-4 West Penetone Qualchem 87932 Qualchem X-It PreKote PreKote Industries, Inc. Due to time constraints, it is not possible to test all of the above cleaners prior to the compliance deadline. Therefore, based on available chemical and testing data, SAIC recommended that methyl propyl ketone (MPK), LPS 104F, and Pensolv K4HP be further tested according to the performance specification and implemented in the maintenance facilities based on the results.

Spray Gun Cleaning

Following painting and some sealant applications, Robins AFB personnel are required to clean the spray guns and other equipment associated with the coating operation. The cleaning of spray guns and other coating application equipment are regulated according to NESHAP Title 40, Part 63, Subpart GG-National Emissions Standard for Aerospace Manufacturing and Rework Facilities, sections 63.744, 63.749, 63.751, and 63.752. All cleaning operations using HAP-based solvents must comply with these paragraphs. Spray gun cleaning operations in the C-130, C-141, C-5, and F-15 aircraft directorates have been targeted for replacement with compliant systems.

Process Evaluation and Alternative Identification. The TRIAD approach was modified slightly to address the spray gun cleaning operations in the aircraft directorates on Robins AFB. Due to the short time constraints and complexity of testing new solvents for cleaning coatings from the equipment, Robins AFB and SAIC agreed to focus on identifying, testing, and implementing compliant cleaning equipment in accordance with the above referenced regulations. Current spray gun cleaning operations were evaluated in the applicable directorates, investigating the equipment and solvents used in the processes. A baseline, including information on chemical characteristics, regulations, fire hazards, safety, exposure limits, and cost, was developed against which alternatives were compared. General performance requirements were also solicited from Robins AFB shop personnel to address preferred features on alternative equipment. Finally, SAIC addressed the NESHAP regulations as they apply to spray gun cleaning.

Based on the performance requirements and preferences reported in the baseline, SAIC identified several pieces of compliant equipment. The equipment is broken into three types: 1) integrated gun washer/solvent reclaimer systems, 2) gun washer units, and 3) solvent reclaimers. The vendors, models, and costs are presented in Table 3.

Table 3

Spray Gun Cleaning Equipment

Vendor Model Cost Integrated Gun Washer/Solvent Reclaimer Systems Becca 009701 Gun Washer/ Reclaimer $10,495.00 009700 Gun Washer/ Reclaimer $8,995.00 Doumar DGWRS3 Gun Washer/ Reclaimer $6,999.10 Omega GWRS-3AS-1-2 Gun Washer/ Reclaimer $5,999.00 Gun Washer Units Binks 40-3550 Gun washer $1,250.00 Graco 112-636 Gun Washer, Premium Model $1,535.97 112-635 Gun Washer, Standard Model $951.93 112-634 Gun Washer, Economy Model $615.04 Herkules GW/R-3-100-SS-T $1,995.00 GW/R-100-SS-T $1,895.00 Safety-Kleen2 1111- Combination Spray Gun & Equipment Cleaner (#077) †† Solvent Reclaimer Units Becca Beccaclean-7 Model 009725 $5,595.00 Beccaclean-5 Model 009711 $4,495.00 Binks 40-3500 Reclaimer $5,200.00 40-3545 Reclaimer $2,850.00 CB Mills MICRO 7.5 $7,500.00 Doumar DS12E Reclaimer $2,699.00 PBR Industries IRAC AV 30 XE $5,493.00 Based on quality and efficiency of design, ease of use, and compliance with both NESHAP regulations and Robins AFB requirements, SAIC has recommended that the Becca 009701 Gun Washer/Reclaimer system be purchased and prototyped. While it is the most expensive system, it offers capabilities others do not, including a reclaimer with an LED readout, computer diagnostic capability, and a 6 gallon capacity boiler (as compared to 3 gallon boilers on other units). While gun washer/reclaimers systems are appropriate for large use facilities, smaller operations can effectively use gun washer only units in their processes. All of the units evaluated had similar capabilities, but the Herkules GW/R-3-100-SS-T most closely matched Robins AFB personnel's

requirements. Both of these units are being purchased will be prototyped tested and evaluated for implementation.

Depaint

The depaint or paint stripping of F-15 wings and stabilizers is regulated by the Aerospace NESHAP. Currently, methylene chloride and phenol-based paint strippers are used to remove the coating systems from these parts. The depainting of parts not normally removed from aircraft is regulated under 40 CFR 63, Subpart GG, National Emissions Standards for Aerospace Manufacturing and Rework Facilities, section 63.746. Robins AFB has also targeted the depaint operations for replacement in accordance with their HAP and TRI reduction programs.

Process Evaluation and Alternative Identification. As a first step in identifying alternatives to the depaint processes, the current operation was thoroughly evaluated and a baseline developed against which to compare potential replacements. The baseline formed a benchmark and included information on the chemical characteristics of the current products, regulations, substrates and paint systems, fire, safety, and exposure hazards, and cost. Products currently being used in the TI industrial support directorate depaint facility are presented in Table 4.

Table 4
Current Depaint Products
Paint
Remover Primary Hazardous
Constituents Classification:
TRI or HAP B & B 1567C Methylene Chloride
Phenol Yes
Yes Yes
Yes Cee Bee A-236 Methylene Chloride
Methanol
Toluene Yes
Yes
Yes Yes
Yes
Yes Cee Bee A-458 Methylene Chloride Yes Yes Cee Bee R-256 Methylene Chloride
Phenol Yes
Yes Yes
Yes HT-2230 Ethylene Glycol Butyl Ether
Ethanolamine Yes
No Yes
No PR-3400 Methylene Chloride Yes Yes Analysis of the process focused on the chemical characteristics of the products currently being used for depainting, the paint systems being removed, and the substrates from which paint was being stripped. Common substrates include aluminum alloys, titanium, boron epoxy composite, and graphite epoxy composite. The paint system being removed from the F-15 wings and stabilizers is comprised of epoxy primer, MIL-P-23377, and polyurethane topcoat, MIL-C-85285. Based on the evaluation of the current process and review of applicable standards, SAIC developed performance criteria against which alternatives are compared. The criteria include applicable testing to determine stripping efficiency, material compatibility, rinsibility, flammability, and other chemical characteristics.

Following the information gathered during the process evaluation and development of the performance criteria, SAIC performed an extensive literature search to find applicable stripping materials. As with the hand-wipe process, potential alternatives were identified from existing testing and performance data as gathered by other ALCs and OEMs. The organizations contacted include Ogden, San Antonio, Oklahoma City, and Sacramento ALCs, Lockheed (Texas and Georgia operations), Boeing (California and Washington operations), and Northrop Grumman (California and Georgia operations). From these contacts and vendor searches, an extensive list of paint stripping products were researched and evaluated. After eliminating many of the products due to composition, pH, viscosity, and flammability, a short list of paint stripping products was designated for further evaluation and testing. This list is provided in Table 5.

Table 5

Potential Depaint Alternatives

Product Manufacturer Product Manufacturer B & B 5151B

Benzyl alcohol

Proprietary Ingredients B&B Tritech, Inc. PREP RITE

N-methyl Pyrrolidone

Triethanolamine Ecolink, Inc. B & B 9575

Benzyl alcohol

Ammonium hydroxide

Aromatic hydrocarbon

Proprietary Ingredients B&B Tritech, Inc. SR-145

Ammonia

Benzyl alcohol

Proprietary Ingredients Eldorado Chemical Company PR-3170

Ammonia

Proprietary Ingredients Eldorado Chemical Company Turco 6813-E

Benzyl alcohol

Linear alkylated aryl hydrocarbon

Ammonium hydroxide

Anisole

Water Turco Products, Inc. PR-5000

Unknown peroxides

Proprietary Ingredients Eldorado Chemical Company Turco 6840-S

Benzyl alcohol

Linear alkylated aryl hydrocarbon

Ammonium bicarbonate

Water

Surfactant Turco Products, Inc. PR-5555 (PR-3170/PR-5000)

Ammonia

Unknown peroxides

Proprietary Ingredients Eldorado Chemical Company Turco 6867

Benzyl alcohol

Linear alkylated aryl hydrocarbon

Boric Acid/ Diethanolamine

Ammonium hydroxide

Proprietary Ingredients

Water Turco Product, Inc. Based on SAIC's evaluation, all of the above listed products are recommended for further testing in accordance with the performance criteria. Due to short time constraints, the list of products to be tested may be reduced to facilitate compliance with the 1 September 1998 implementation date.

CONCLUSION

Project TRIAD is the most comprehensive effort ever launched to provide regulatory compliance through pollution prevention initiatives on Robins AFB. Instead of stop-gap measures and control technologies, the Robins AFB-SAIC partnership is eliminating the compliance burden and liability at the source. TRIAD successfully interweaves the requirements of the ESOH community and systems engineers, providing a flexible methodology to attack compliance issues and hazardous material usage. Project TRIAD is producing the necessary performance specifications, testing protocols, and implementation plans to bring about process changes and eliminate the compliance issues. A three-way parnership-systems engineers, the ESOH community, and SAIC-developed through Project TRIAD, continues to meet the needs of Robins AFB.

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Camp Lejeune: Achieving Compliance through Pollution Prevention

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Abstract

Despite the numerous environmental challenges associated with efficiently managing a very large, diverse operating installation, Marine Corps Base Camp Lejeune, North Carolina, has made prodigious advances in achieving environmental compliance through pollution prevention and is also continuing to plan and implement pollution prevention projects that are targeted to further reduce compliance issues. In 1997, MCB Camp Lejeune and CH2M HILL undertook a major pollution prevention effort to inventory all major industrial processes, identify the processes that most impact environmental compliance, and make targeted efforts at conducting P2OAs for those processes.

From this effort and from past P2 initiatives, Camp Lejeune has reduced the number of EPCRA reported chemicals from four to one. In addition, Camp Lejeune has reduced hazardous waste generation by over 40%, pesticide/herbicide usage by 95% and solid waste disposal by 30%.

The Environmental Management Department at Camp Lejeune is continuing to be proactive in identifying additional pollution prevention opportunities to further reduce EPCRA reporting requirements, hazardous and solid waste generation, and hazardous air pollutants (HAPs). Camp Lejuene is investigating innovative procurement techniques to reduce solid waste generation by an additional 25%. Camp Lejeune is also investing in a significant program to implement a hazmat pharmacy utilizing the hazardous substance management system (HSMS) to control the procurement and use of hazardous materials.

This paper will detail the pollution prevention programs implemented by Camp Lejeune and the direct impact on environmental compliance issues.

Marine Corps Base (MCB) Camp Lejeune, located in southeastern NC on the Atlantic Coast, houses the largest concentration of Marines and Sailors in the world. To achieve its mission, MCB Camp Lejeune operates many industrial processes at numerous locations throughout the installation's 153,000 acres.

MCB Camp Lejeune houses the headquarters of Marine Forces Atlantic, command of all East Coast Marine Corps forces. There are also five major Marine Corps and two Navy commands, and one joint command housed at the installation. The five major Marine Corps commands are: Command Element, II Marine Expeditionary Force (II MEF), which now includes the 2nd Surveillance, Reconnaissance, and Intelligence Group (SRIG), which conducts operational planning and produces and releases intelligence information for Fleet Marine commands.

2nd Marine Division is the ground combat element of the II MEF.

2nd Force Service Support Group is the combat service and support element of the II MEF.

II MEF Augmentation Command augments and reinforces active component headquarters and the Marine Air Group command element.

Marine Corps Base owns the real estate, operates entry-level formal training schools, and provides training and logistical support for tenant commands. The Naval Hospital and Navy Dental Center are tenant commands that provide primary medical and dental care to Marines and sailors and their family members and retirees.

MCB Camp Lejeune supports approximately 144,000 Marines, Sailors, and families. The predominant industrial activities at MCB Camp Lejeune and the Marine Corps Air Station New River (located just northwest of Camp Lejeune) involve the operation, maintenance, and repair of tactical equipment and vehicles. There are also large material uses and wastes generated from training exercises and aircraft maintenance activities.

Pollution Prevention Study - 1997

During the 1997 P2OA, 20 major pollution-generating processes were identified as the most likely to result in additional feasible P2 opportunities from all the known activities at MCB Camp Lejeune. These processes were identified by first listing as many of the pollution-generating processes as possible. These processes were identified using hazardous waste records and reports, the base's SARA Title III Report for TRI emissions, input from base personnel including EMD staff, and information gathered during site visits.

These processes were then prioritized on the basis of 1) regulatory significance, 2) potential pollution prevention opportunities, and 3) hazardous material use/waste generation. The 20 processes with the highest priority were then evaluated in the 1997 P2OA. The ranking of the top 20 processes were as follows:

Process Assessment Score Process Assessment Score 1) Large Parts Cleaners 46.75 11) Environmental Contracting 41.5 2) Small Parts Cleaners 44.88 12) Pesticide/Herbicide Use 40.63 3) Tactical Equipment Painting 43.5 13) Adhesive Applications 40.25 4) Aircraft Painting 43.5 14) Battery Operations 39.75 5) Paint Stripping 42.75 15) Large Parts Abrasive Blasting 39.25 6) Reprographics/Printing 42.25 16) Landfill Gas Recovery and Reuse 38.25 7) Small Weapons Cleaning 42.25 17) Fire Training 38 8) Tracked Vehicle Cleaning 42.25 18) Small Parts Abrasive Blasting 38 9) Cannon Weapons Cleaning 42.25 19) Brush/Roller Painting 37.25 10) Water Reuse 42 20 Commercial Equipment Painting 36.63

Camp Lejuene's P2 Activities and Compliance Effect

During the 1997 P2OA, P2 opportunities were identified for each of the 20 pollutant-generating processes listed above to allow the base to meet P2 goals and assist in achieving compliance with various environmental regulations. These opportunities included process efficiency improvements, material substitutions, inventory controls, contracting changes, and housekeeping improvements. The following details regulatory compliance issues faced by MCB Camp Lejeune (and the MCAS New River) and those P2 activities that have led to improved ease in meeting compliance requirements.

Compliance Issues faced by MCB Camp Lejeune

As a large, industrial installation, Camp Lejeune faces many environmental compliance issues. Those compliance issues for which Camp Lejeune has used pollution prevention to facilitate compliance include Emergency Planning and Community Right to Know Act (EPCRA), Resource Conservation and Recovery Act (RCRA), Clean Air Act and National Emission Standards for Hazardous Air Pollutants (NESHAP), the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Occupational, Safety, and Health Association (OSHA) requirements, and Executive Order 12856.

EPCRA

To position Federal agencies as leaders in pollution prevention, President Bill Clinton signed Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements" on August 31, 1993. As a result, all Federal installations must comply with the requirements of EPCRA of 1986 and the Pollution Prevention Act of 1990. Therefore, Camp Lejeune must annually complete EPCRA Toxic Release Inventory (TRI) Reports for both MCB Camp Lejeune and the MCAS New River. In addition, EO 12856 also mandated that Camp Lejeune reduce reportable TRI chemicals by 50%.

In 1995, Camp Lejeune completed a TRI report for 1994. As a result, four TRI chemicals were found to exceed reportable threshold quantities in 1994 and were reported in Camp Lejeune's 1994 TRI report. These chemicals are methyl ethyl ketone, CFC 113, ethylene glycol, and methylene chloride. Approximately 94,000 pounds of these chemicals were procured for use at Camp Lejeune. For calendar year 1996, Camp Lejeune was required to report only ethylene glycol. The total quantity reported was just over 23,000 lbs.

Camp Lejeune has thus reduced the chemicals reported from four to one and has reduced reportable TRI chemicals procured by approximately 75%. Pollution prevention activities that have resulted in these impressive achievements include the following:

Methyl Ethyl Ketone (MEK). MEK is a component of paints, solvents, and adhesives. MEK use has been reduced primarily through the use of MEK-free solvents and high solids paints that also contain less or no MEK. Several shops have used MEK for de-painting and degreasing parts. This practice has been stopped base-wide and has been replaced by either small cold degreasing units (using premium Type I solvent with filtered units) or using non-toxic citrus-based cleaners.

CFC-113. CFC-113 is found in cleaning solvents; corrosion, and moisture preventative compounds; and adhesives. CFC-113 releases have been reduced to below reportable quantities through the identification of CFC-113-free cleaning products. In addition, through the use of

corrosion, lubricant, and preservative (CLP) that is free of CFC-113 ("new" CLP) helped to significantly reduce CFC-113 use on the installation.

Methylene Chloride. Methylene Chloride has been used as the MCAS New River installation to strip grease and paint from aircraft parts that require non-destructive inspections. Camp Lejeune has significantly reduced the amount of methylene chloride that is used through bath life extension and initial part preparation. Camp Lejeune personnel determined that methylene chloride baths were replaced before the useful bath life was identified. In addition, parts that contained caked grease and oils were wiped down with rags prior to entering the methylene chloride tanks.

Camp Lejeune is in the process of procuring an N-Methyl Pyrrolidone (NMP) based heated single stage cleaning system. The system incorporates a fine particle filter system that removes contaminants and extends the bath life.

This effort will alleviate Camp Lejeune's need to meet and maintain any maximum available control technology (MACT) requirements under NESHAP.

Ethylene Glycol. Ethylene glycol is found in antifreeze used in installation vehicles. Camp Lejeune has reduced the amount of ethylene glycol by placing better controls on access and use of antifreeze. Camp Lejeune is still exceeding threshold quantities and may identify recycling technologies that would meet tight quality specifications.

RCRA

Hazardous Waste. RCRA establishes guidelines and standards for hazardous waste generation, transportation, storage, and disposal. Camp Lejeune must manage hazardous waste generated according to the requirements set forth by RCRA. Camp Lejeune must prepare a biennial report that compiles all hazardous wastes that are generated at the installation. In addition, EO 12856 requires that by 1999, Camp Lejeune reduce its hazardous waste generation and disposal by 50% from a 1992 baseline. Because of the regulatory and economic impact of hazardous waste generation can have on the installation, it is a priority of Camp Lejeune to reduce hazardous waste generation. Hazardous waste is generated from a variety of sources at MCB Camp Lejeune and the MCAS New River. Hazardous wastes generated can include:

used decontaminating agents
decontamination kits
acids (generated through vehicle/battery maintenance)
solvents
adhesives/resins
paint-related wastes
alcohol(s)
pesticides/herbicides
other intermittent/one-time hazardous wastes (oxygen canisters, etc.)

Camp Lejeune has reduced the amount of solvent waste generated by 80% since 1992. Pollution prevention initiatives that have led to this reduction include the use of distillation technologies for reclaiming and reusing solvents for painting/paint clean-up. In addition, many shops have formed their own internal micro "pharmacy" system. Through these micro pharmacies, shops have better accountability on solvents and has helped reduce the overall use. Camp Lejeune is

also using Safety-Kleen's Type I Premium solvent that is below RCRA ignitability criteria. All of the solvent tanks use particle filters that help extend the bath lives.

Camp Lejeune has reduced the amount of paint related wastes by nearly 50% since 1992. The major initiative that led to this reduction includes the tighter control of paint use through the micro-pharmacy systems. In addition, Camp Lejeune has made significant progress by reducing the amount of shelf-life expired paint waste that was generated.

Camp Lejeune has also reduced the amount of pesticide/herbicide waste generated by over 90%. They have been able to achieve these reductions through the use of baits, as needed application practice and routine inspections, and overall optimum management practices.

Through these P2 initiatives, Camp Lejeune and MCAS New River has reduced combined hazardous waste generation by 40%. These reductions have meant less potential for regulatory compliance problems, potential for spills, and overall lower reporting requirements.

EO 12856

Through EO12856, Camp Lejeune and other DoD facilities must meet provisions of the Pollution Prevention Act of 1990. The DoD has mandated all of their installations to meet measures of merit (MOMs) which are as follows:

By 1999, reduce releases and off-site transfers of toxic chemicals 50 percent from a 1994 TRI baseline.

By 1999, reduce the disposal of hazardous waste 50 percent from a 1992 baseline.

By 1999, reduce the disposal of non-hazardous solid waste 50 percent from a 1992 baseline.

By 1999, recycle 50 percent of non-hazardous solid waste generated.

By 2000, reduce the number of units that utilize ozone-depleting chemicals (ODSs) 20 percent from a 1995 baseline.

By 2000, reduce the quantity of ODSs at installation by 20 percent from a 1995 baseline.

Ensure 75 percent of DoD acquisitions of new, non-tactical vehicles are alternatively fueled vehicles by the end of calendar year 1999.

Ensure a 50 percent reduction in the active ingredients of pesticides/herbicides from 1993 inventory baseline levels by the end of fiscal year 2000.

Camp Lejeune is well on its way to meeting all P2 goals. Through 1996, Camp Lejeune has met goals for EPCRA chemicals and pesticides/herbicides. A status summary is provided in the table below:

Simplified Summary of MCB Camp Lejeune and the MCAS New River's Pollution Prevention Program
Pollution Prevention Program Elements EPCRA (lb) Haz Waste (lb) Solid1 Waste Disposal (ton) Solid2 Waste Recycling (ton) Pest/
Herb
(lb) ODS
Units ODS Quantity (lb) AFV (vehicles/yr) Baseline Quantity
93,771 446,787 83,800 83,000 4,811 24,948 84,905 280 1996 Inventory
Quantity 23,215 264,898 58,700 24,300 246 24,882 81,007 0 Percent
Remaining 0% 10% 20% 21% 0% 19.7% 15% 75% 1 9.9% remaining on a Fiscal Year basis.
2 23.8% remaining on a Fiscal Year basis.

Conclusions

Considering the vast operations and sheer size of an installation such as MCB Camp Lejeune, controlling hazardous material use, hazardous waste generation, and solid waste is a formidable task. Camp Lejeune has been very proactive relative to its pollution prevention responsibilities and has taken the installation to a higher level in achieving compliance through the pollution prevention

program. Through pollution prevention, Camp Lejeune has lessened reporting requirements, reduced costs in hazardous material and waste operations, reduced solid waste reaching its landfill, and has reduced the manpower needed to track compliance maintenance. The expenditures saved in these programs have helped support further pollution prevention initiatives.

Session XVI
Incorporating P² Into Acquisition

Session Chairpersons:

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Ms. Cindy Hood, HQ AFCEE/EQT

Incorporating Pollution Prevention into the Acquisition Process

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Objective: To illustrate the importance for operators and maintainers of weapons systems and associated equipment to assume total cost ownership.

Background: In the not too distant past, weapons systems were developed and fielded with little to no input from the organizations that were going to operate and maintain them. The materials designed into the system, either resident on the weapon system or mandated by technical order for use in the repair and preventive maintenance of the system, did not take into consideration the costs associated with using and disposing of many of these materials. Environmental regulations have increased significantly over the last few decades, as has our knowledge about the impacts of using certain materials. These changes have reduced detrimental effects to the environment and provided safer working conditions for our personnel, but not without a cost. If we can further reduce our use of these hazardous materials through pollution prevention efforts, the cost of the weapon system over its lifetime, with all the associated costs to maintain and dispose of it, will be greatly reduced. With our budgets tightening each year, putting our efforts into finding less costly as well as less hazardous materials will reduce the life cycle cost of the weapon system. Whether it is incorporating these changes into new aircraft or existing ones, the acquisition community is the body of professionals that provides us with the tools we need to accomplish this mission. Process owners must learn to effectively communicate their needs to the acquisition community and partner where we can to facilitate the entire process. Facilitating the reduction of costs associated with Environmental, Safety and Occupational Health (ESOH) impacts upon our weapons systems is a major goal of AETC's Logistics Environmental Management office. Once all costs associated with maintenance are understood, inclusive of environmental, safety and occupational health requirements, process owners are best positioned to help reduce/eliminate these costs.

Current Results and Continuing Development: ESOH cost reduction/elimination is achieved through active participation in the pollution prevention process by the process owner in partnership with the acquisition community. The following text discusses a variety of vehicles that help organizations make their weapons systems needs known to the acquisition community, an in-turn develop better partnering opportunities.

1. **Partnerships with environmental collocates within the Systems Program Offices**

AETC is responsible for over 1600 aircraft representing almost two dozen different types of weapons systems. This diversity gives us the opportunity to discuss issues with many different system program offices and share that information with others that might benefit. Developing professional relationships through face-to-face visits, electronic mediums and telephone discussions keeps the lines of communication open. This office has just begun to expand into this area. We are currently working with personnel in the T-6, C-17, F-22 SPOs as well as in our own backyard since AETC has full responsibility for the T-37s and T-38s. One initial goal was to determine what hazardous materials are resident on the weapons system and what materials are used or generated during maintenance actions.

2. Membership on Environmental Working Groups

One of the major areas of our acquisition program is membership and participation with several environmental working groups. This allows us as a customer to play an active role on issues that each group is working and to submit additional requirements into the process.

2.1 Weapon System Pollution Prevention Center Working Group

One of the key organizations this office is involved with is AFMC's Weapon System Pollution Prevention Center Working Group, a valuable group for interaction both within and outside the AF. This group interfaces with DOD and commercial enterprises and provides an avenue to cross-feed information across a widely diverse group. We have found that our participation is very much welcomed and encouraged. Because the commands, i.e., AFMC and AETC, are so different in their structure and mission, the interaction between the two has been highly educational and beneficial. In April of this year, AETC had the opportunity to host this group in San Antonio, Texas. This is the first time an Air Force organization outside of AFMC has hosted this event and gave AETC the chance to showcase the command and its mission. This group welcomes participation by all interested parties, especially "customers" of AFMC. The overall goal of this group is to find "*Joint Solutions to Common Problems.*"

2.2 Environmental, Safety and Occupational Health Technical Planning Integrated Product Team (ESOH TPIPT)

Another key organization working to find environmental, safety and occupational health solutions for the Air Force is the ESOH TPIPT. This organization's charter clearly states the goals of this group. Knowing that the Air Force vision to build the world's most respected air and space force can be seriously impeded by ESOH issues, this organization is diligently working to identify ESOH related issues and effect changes that will reduce cost, minimize mission impact, and increase performance. The ESOH TPIPT planning process identifies and collects validated ESOH needs (near and long term) for the Air Force, finds and assesses solution options, and offers integrated solutions to customers. Customers are ultimately responsible for their submitted needs and can employ or reject the development plans provided by the ESOH TPIPT at any time.

The ESOH TPIPT consists of an integrated team of operators, policy and mission support developers, planners, engineers, scientists, logisticians, test engineers and program managers. MAJCOMs appoint a representative from each of the weapon system (logistics) and infrastructure (civil engineering) communities. Both representatives attend ESOH TPIPT meetings and participate in activities. On matters regarding ESOH TPIPT operations and process, MAJCOMs are the only TPIPT members with a vote (if voting is required) and each MAJCOM has a single vote.

2.3 F-22 Environmental Safety Health Working Group (F-22 ESHWG)

The first new aircraft acquisition working group, probable forerunner for the Joint Strike Fighter, to actively recruit using organizations and solicit their input and involvement. The leadership are strong advocates for safety and Bioenvironmental engineering representatives to become involved. The main goal of this group is to field this new weapon system as smoothly as possible while maximizing the benefits of lessons learned. A major effort is underway to glean information from the maintenance unit at Edwards AFB where the aircraft is undergoing flight test and use this data to improve the beddown operations at future locations.

2.4 C-17 Weapon System Expanded Pollution Prevention Integrated Product Team

This is an active integrated product team for a recently fielded weapon system. This group meets about four times each year in various locations and attracts and encourages participation from others working with large airframes. Our best success has come from sharing problems and success stories with others throughout the AF and DOD.

2.5 Propulsion Environmental Working Group (PEWG)

A very active environmental working group dedicated to issues within the propulsion arena, with active participation by many diverse agencies and contractors. These folks are working together diligently to reduce hazardous materials and waste streams from propulsion systems. Programs and projects being considered and worked under this group are increasingly focusing on business factors, including return on investment considerations

3. Redefinition of the Technical Needs Survey Process

When the technical survey process was first initiated, personnel submitted needs directly into HSC/XRE, the Human Systems Center at Brooks AFB, TX. It was entirely possible that the need would be assigned to a lab and worked without any one at the owning installation or MAJCOM having any knowledge of the project until after already underway or even competed. "Solutions" would be fed back to the command and offer a solution to a problem that may or may not even exist at that time. With no MAJCOM "buy-in" this process offered the potential for a great deal of wasted time and money.

Through the efforts of many individuals, this issue was reengineered to ensure that all technical needs are validated at base level before submitting to the respective major command. Figure 1

shows the revised process. Tied to this process AETC has formally implemented standardized evaluation criteria that allow both the individual bases and the MAJCOM to equitably rack and stack proposed initiatives/programs.

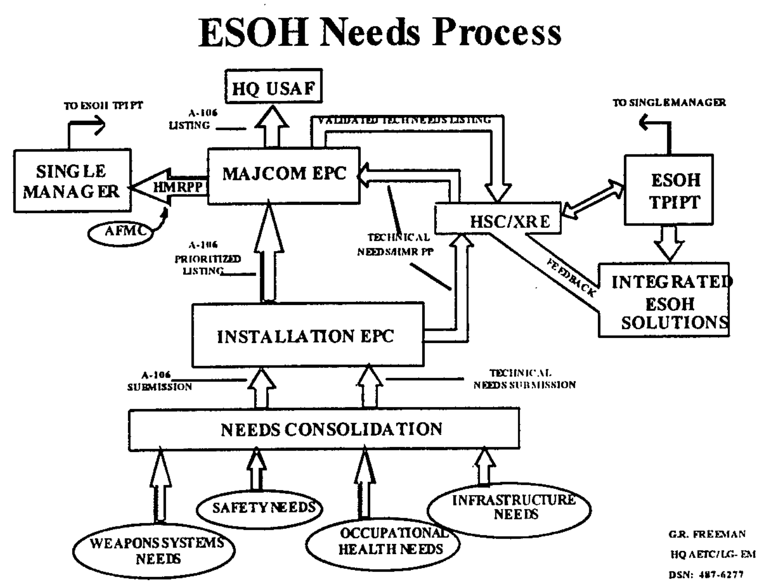

Figure 1

4. **Instilling change from the bottom up through the Shop-Level Pollution Prevention Training Program**

Many of the best ideas are born in the shops, from those closest to the action. But if these individuals don't know how "the system" works, how can they get the "right" audience for their ideas? To provide our shop personnel with the tools needed to initiate change and form the first foundation building block of our overall program, Shop-Level Pollution Prevention Training was developed to empower shop workers by instructing them in four basic subject areas: what pollution prevention is, familiarization with legal drivers, how P2 applies to their individual shop operations, and how to generate ideas and where to go for help.

The training manual is a road map for this process. When the course was first introduced, LG-EM brought the LG Environmental Coordinators from each AETC installation to Randolph AFB TX for a train-the-trainer session. This provided each base representative with the tools to go back to his/her installation and teach the program to all shop level personnel in the logistics community. This program has been lauded by many, one of the most notable, Mr. Tad McCall, Deputy Undersecretary of Defense for Environmental Security. In a little over a year, almost 10,000 "loggies" have received the training. As a direct result of this effort, AETC has experienced a phenomenal increase in recommendations for improvement from the field. Other

installations have requested this training and have subsequently obtained it "real time" from the HQ AETC/LG-EM Website.[1]

An overview of the current training manual follows, updates are in the works, and projected to be incorporated by Oct 98. The first section introduces the student to the reasons why P2 is so important today, tracing the deadly results unmanaged development can have on an environment. Then, it takes a look at how Congress has approached our environmental problems, initially focusing on pollution control and transitioning over the years to target efforts in preventing pollution altogether. Some of the most prominent environmental laws are touched on followed by a discussion of what P2 is and what it's not.

The next subject area talks about the concept of process groups and an overview of a process guide. These guides discuss the major activities in detail relevant to each group and how to look at the processes within each activity to help develop P2 opportunities and possible solutions. The use of specific examples adds clarity.

The third subject area identifies a multitude of existing resources for use in developing potential pollution prevention options. Here, the student is exposed to environmental organizations, computer programs, reports, handbooks and an extensive listing of helpful sites on the World Wide Web.

With all the foregoing background under the student's belt, the last subject area addresses how to generate new options. It helps the individual develop a logical thought process, helps assess the avenue that needs to be explored and identifies who can help. From technical order changes to technical need survey inputs, this area explains how to follow through on an idea to help make it a reality. This section includes many examples of completed forms to help the reader through the process.

Benefits/Projects: The efforts of the logistics environmental management office are paying off. A study initiated by this office reduced NESHAP "major" source bases from 13 to 3 providing a tangible cost avoidance of $20 M to the command and the Air Force. This is real taxpayers' money that would have to have been spent for installation upgrades to meet the more stringent requirements spelled out in the NESHAP regulation. The detailed study of air emissions showed that most of our installations emit hazardous air pollutants in quantities well under the limits that trigger mandatory compliance with NESHAP. AETC has also benefited from another $11.2 M cost avoidance of corrosion control facility upgrades through the introduction of high solid low VOC paints. One of our ongoing projects is an initiative to secure acceptable replacement of Alodine pre-coat. The logistics community is testing two pre-coats on several T-38s and T-37s at Randolph AFB and Columbus AFB. Additionally, we are teaming with AFMC on a Joint Group - Acquisition Pollution Prevention (JG-APP) project to research and test the use of non-chromated primers on two AETC F-15's at Tyndall AFB, FL.

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[1] HQ AETC/LG-EM's Website can be found at http://www-logistics.aetc.af.mil/maint/enviro/homepage.htm.

Through our submissions into the technical need survey (TNS) process the AETC ESOH community has mobilized Air Force resources to work AETC weapons systems issues; over \$37.6 M funded to date by AFMC. One success story is the result of a TNS that identified the need for an alternative for Ethylene Oxide Sterilization. This process is used to sterilize medical equipment and uses Freon, a Class 1 ozone-depleting chemical (ODC). The TNS evaluation identified the commercial sector as a source and Wilford Hall Medical Center found units to test. After a one-year test, the "new" sterilizers proved to work well and be much more cost effective to operate. The payback period was only 1.06 years and the follow-on savings will be just over \$100 K annually.

The working groups are making progress as well. The F-22 ESHWG, for example, was instrumental in eliminating cadmium from the F-22 landing gear. These are some examples of the positive results that are happening because the process owner is assuming responsibility and getting involved.

Conclusion: Active participation in all phases of the acquisition process is already providing significant tangible dividends and will continue to facilitate better decisions throughout the entire weapons system life cycle. The end result will be the minimization of ESOH costs thereby lowering the environmental compliance "bill" and freeing up funds for force modernization and other critical Air Force programs.

HAZARDOUS MATERIAL CONTROL CENTER

HAZARDOUS MATERIALS CONTROL CENTER

Fort Carson , Colorado

Information Brief

Presented By: Ms. Anju Chugh

Hazardous Material Control Center

"HazMat Pharmacy"

PURPOSE:

To ensure proper management of Hazardous Material by consolidating & tracking the requisition, receipt, storage, distribution & disposal of all Hazardous Material at Fort Carson.

BENEFITS:

- → Improved Mission Readiness
- → Improved Economics
- → Environmental Compliance
- → Improved Worker Safety

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

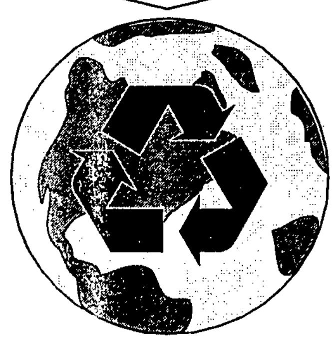
HOW IT WORKS:

ALL INCOMING & EXCESS HAZARDOUS MATERIAL

UNIT PICK UP

EMERGENCY DELIVERIES

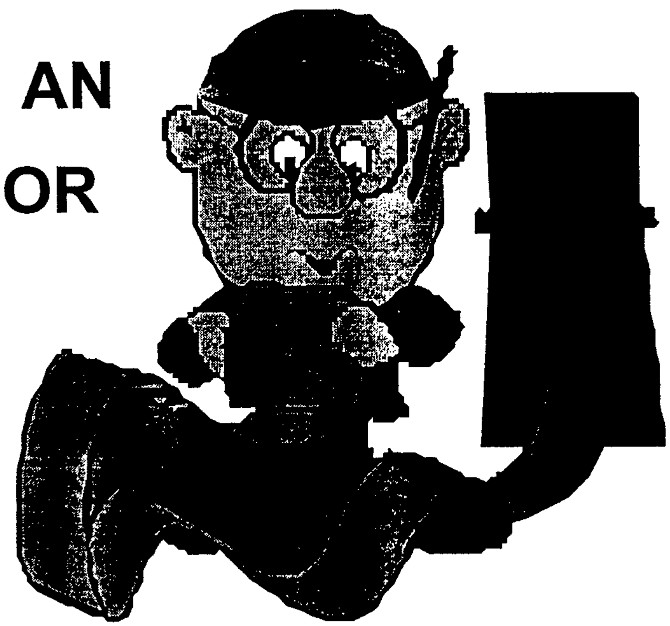
DISPOSAL



HAZARDOUS MATERIAL CONTROL CENTER

HAZARDOUS SUBSTANCE MANAGEMENT SYSTEM
(HSMS)

PURPOSE: TO PROVIDE AN AUTOMATED TRACKING TOOL FOR THE HAZARDOUS SUBSTANCE MANAGED BY THE PHARMACY.



BENEFITS:

TRACKS HAZARDOUS MATERIAL/WASTE

ASSISTS IN MEETING REPORTING REQUIREMENTS AS MANDATED BY:

- *THE EMERGENCY PLANNING & COMMUNITY RIGHT TO KNOW ACT (EPCRA)*
- *THE POLLUTION PREVENTION ACT (PPA)*

HAZARDOUS MATERIAL CONTROL CENTER

PROGRAM ISSUES

GARRISON
QUANTITIES?

CONTINGENCIES
HOW MUCH?
HOW QUICKLY?

EQUIPMENT
WHAT?

PERSONNEL
FUNDING?
TRAINED?

SUPPLY
SARSS?
STOCKS?

COMPLIANCE
EPA/OSHA/DOT?
CO?
DOD?
DA?
Fort Carson?

ORGANIZATION
LOGISTICS?
ENVIRONMENTAL?

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

ORGANIZATION:

Issue: The Hazardous Material Control Center is a Logistics function with Environmental benefits.

Fort Carson Solution:

- ⇨ Integration of HMCC Program into the DOL
- ⇨ Coordination with DECAM for Environmental oversight
- ⇨ Contracted Operation

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

PERSONNEL:

Issue: Who to hire? How many? How to fund?

Fort Carson Solution:

⇨ Staffing Levels: 1 Mgr, 1 Systems Mgr, 1 Supply Tech, 3 Env Techs, 2 Data Entry

⇨ Qualifications: Environmental, Supply and Automation

⇨ Funding: Installation Funded (ABC)

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

EQUIPMENT:

Issue: What set up is required for the HMCC?

Fort Carson Solution:

- ⇨ Storage Facilities: HazMat Warehouse; Storage Lockers
- ⇨ PPE: Personal Protective Equipment
- ⇨ Vehicles: Trucks, Materiel Handling Equipment
- ⇨ Office Space: Administrative Area
- ⇨ Hardware: HSMS, SARSS

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

SUPPLY:

Issues: How to interface the HMCC with the Army Supply System? What items to stock?

Fort Carson Solution:

- ⇨ Establish the HMCC as a SARSS-1 Site
- ⇨ Establish procedures that utilize existing automation
- ⇨ Stock all Hazardous Material

HAZARDOUS MATERIAL CONTROL CENTER

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HOW IT WORKS:

GARRISON:

Issue: How are the soldiers supported by the HMCC in Garrison?

Fort Carson Solution:

⇨ Schedule an "Amnesty" Day @ BN/SQDN level
⇨ Set up a 7 day Garrison Stockage Level (GSL) in unit area
⇨ Scheduled pick up of replenishment stocks once a week, from HMCC
⇨ Establish 7 day Garrison Demand History

HAZARDOUS MATERIAL CONTROL CENTER

Hazardous Materials Control Center

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

CONTINGENCIES:

Issue: How to support units with their training mission?

Fort Carson Solution:

- ⇨ Establish a 15 day Unit Basic Load (UBL)
- ⇨ Maintain the UBL at the HMCC Site
- ⇨ Ensure 24 hour access to HMCC Personnel
- ⇨ Ensure response time meets Installation requirements
- ⇨ Integrate with the G4/DOL
- ⇨ Procure deployable HazMat lockers

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

HOW IT WORKS:

COMPLIANCE:

Issue: How does the HMCC contribute to Environmental Compliance?

Fort Carson Solution:

⇨ The HMCC provides proper storage for the HazMat
⇨ The HMCC personnel ensure proper HazMat mgmt
⇨ All HazMat issues are barcoded, aiding in tracking and accountability
⇨ HSMS facilitates EPCRA and RCRA Reporting

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONCEPT OF OPERATIONS

PHARMACY PROGRAMS:

POLLUTION PREVENTION INITIATIVES:

- ECOLABS, re-refined oil, recycled antifreeze, rechargeable batteries, deployable lockers

PRODUCT SUBSTITUTIONS:

- Introduced over 100 product substitutions

SHELF-LIFE MANAGEMENT:

- Approved 9,522 extensions on 12,425 items ($29,346.51)

DEPLOYMENTS:

- Provide basic loads for unit deployments
- Support deployments, field exercises & real world missions

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC P2 INITIATIVES

ECOLABS:

What? A system/program to reduce cleaning supplies. An ultra dilution system: concentrated cleaning chemicals are diluted for the end user.

How? The HMCC receives the concentrated chemical and dilutes the product to 3 gal containers. These are issued to units who further dispense the product into spray bottles. Units report to HMCC for refills.

Why? Increased HazMat management
Reduced hazardous waste
Simplified safety management
Reduced exposure

RE-REFINED OIL:

What? The vendor provides delivery of re-refined motor oil to customers at a reduced price. Vendor picks up used oil from the installation at no cost - to be used as base stock for the re-refining process.

How? The HMCC requisitions all motor oil for the installation, utilizing the NSN for the re-refined product. Units coordinate for pick up of their used product directly with the vendor.

Why? Cost Effective
Increased Recycling Effort
Centralized Control

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC P2 INITIATIVES

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HAZARDOUS MATERIAL CONTROL CENTER

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HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC P2 INITIATIVES

DEPLOYABLE LOCKERS:

What? Use deployable hazardous material storage lockers for any training exercises and deployments

How? The HMCC maintains a BN/SQDN UBL within these lockers. Issue the locker at time of departure, restock locker at time of return.

Why? Cost Effective
Efficient
Proper storage

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC CONSUMPTION REDUCTION

CONSUMPTION DATA FOR DOL:

SHOP	BEFORE	AFTER
PAINT / BODY	115	59
FUEL INJECTION	36	20
MOBILITY / REPAIR	88	21
GENERATOR	42	25
VEHICLE ELECTRIC	29	19

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC SHELF-LIFE MANAGEMENT

CARC PAINT:

Item: ALIPHATIC POLY CARC: TAN 686

Quantity Onhand: **1472 CANS**

NSN: 8010-01-276-3640

Lot/batch Number: 27l691

Unit Of Issue: 5 Gl Cn

Unit Price: $153.79

Shelf-life Expiration Date: Dec 97

Shelf-life Extension: Dec 98

PROCUREMENT AVOIDANCE:
$226K

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC PROJECTED SAVINGS

CARRY-OVER EXCESS

	FY 99	FY 00	FY 01	FY 02	FY 03
ACQ AVOID	0	750K	750K	750K	750K
EXCESS INV	1,500K	500K	0	0	0
SHELF LIFE EXT	1,400K	450K	0	0	0
POT DISP COST	2,250K	750K	75K	75K	75K
PROD REUSE	1,000K	340K	0	0	0
PROD SUB	200K	200K	100K	50K	50K
SUB TOTAL	3,450K	1,290K	925K	875K	875K
LABOR	500K	500K	400K	300K	300K
FACILITIES	300K	0	0	0	0
NET AVOIDANCE	2,650K	790K	525K	575K	575K

AVOIDANCE OVER THE POM
$5.1M

ADDITIONAL COST AVOIDANCES:

→ ENVIRONMENTAL FINES & PENALTIES

→ CREDIT CARD PURCHASES

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HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC POINT OF CONTACT

**FOR ADDITIONAL INFORMATION,
PLEASE CONTACT:**

MS ANJU CHUGH, HMCC MANAGER

PHONE: 719 526 6013

FAX: 719 526 5587

EMAIL: ACHUGH@ RTP.PES.COM

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- → Improved worker safety

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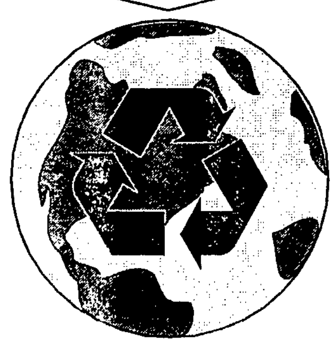
HOW IT WORKS:

ALL INCOMING
& EXCESS
HAZARDOUS
MATERIAL

DISPOSAL

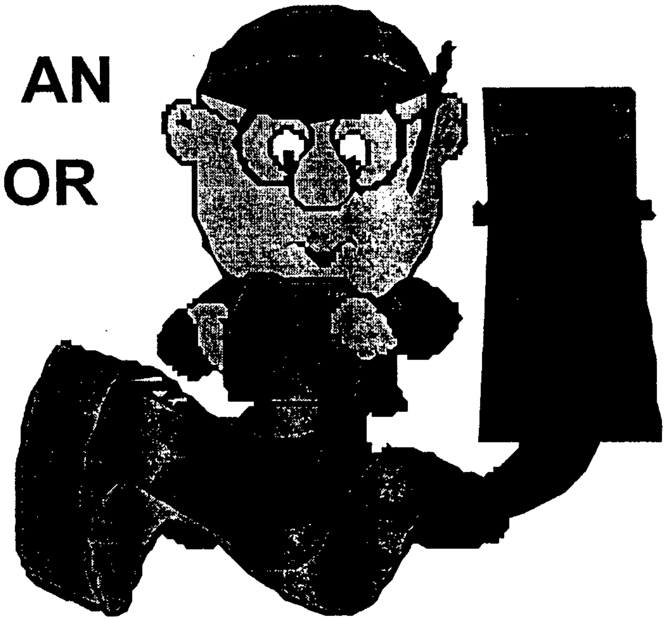


UNIT PICK UP

EMERGENCY
DELIVERIES

Hazardous Material Control Center

Hazardous Substance Management System (HSMS)



PURPOSE: To provide an automated tracking tool for the hazardous substance managed by the Pharmacy.

BENEFITS:

Tracks Hazardous Material/Waste

Assists in meeting reporting requirements as mandated by:

- *The Emergency Planning & Community Right to Know Act (EPCRA)*
- *The Pollution Prevention Act (PPA)*

HAZARDOUS MATERIAL CONTROL CENTER

PROGRAM ISSUES

GARRISON

QUANTITIES?

CONTINGENCIES

HOW MUCH?
HOW QUICKLY?

EQUIPMENT

WHAT?

PERSONNEL

FUNDING?
TRAINED?

SUPPLY

SARSS?
STOCKS?

COMPLIANCE

EPA/OSHA/DOT?
CO?
DOD?
DA?
Fort Carson?

ORGANIZATION

LOGISTICS?
ENVIRONMENTAL?

HAZARDOUS MATERIAL CONTROL CENTER

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HOW IT WORKS:

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- ⇨ Integration of HMCC Program into the DOL
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HAZARDOUS MATERIAL CONTROL CENTER

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Hazardous Material Control Center

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Centralized Control

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Hazardous Material Control Center

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GENERATOR	42	25
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HAZARDOUS MATERIAL CONTROL CENTER

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CARC PAINT:

Item: ALIPHATIC POLY CARC: TAN 686

Quantity Onhand: **1472 CANS**

NSN: 8010-01-276-3640

Lot/batch Number: 27l691

Unit Of Issue: 5 Gl Cn

Unit Price: $153.79

Shelf-life Expiration Date: Dec 97

Shelf-life Extension: Dec 98

PROCUREMENT AVOIDANCE:
$226K

2 94

HAZARDOUS MATERIAL CONTROL CENTER

FORT CARSON'S
HMCC PROJECTED SAVINGS

CARRY-OVER EXCESS

	FY 99	FY 00	FY 01	FY 02	FY 03
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EXCESS INV	1,500K	500K	0	0	0
SHELF LIFE EXT	1,400K	450K	0	0	0
POT DISP COST	2,250K	750K	75K	75K	75K
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PROD SUB	200K	200K	100K	50K	50K
SUB TOTAL	3,450K	1,290K	925K	875K	875K
LABOR	500K	500K	400K	300K	300K
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AVOIDANCE OVER THE POM
$5.1M

ADDITIONAL COST AVOIDANCES:
- → ENVIRONMENTAL FINES & PENALTIES
- → CREDIT CARD PURCHASES

HAZARDOUS MATERIAL CONTROL CENTER

Hazardous Materials Control Center

FORT CARSON'S
HMCC POINT OF CONTACT

FORT CARSON THE MOUNTAIN POST

FOR ADDITIONAL INFORMATION,
PLEASE CONTACT:

MS ANJU CHUGH, HMCC MANAGER

PHONE: 719 526 6013

FAX: 719 526 5587

EMAIL: ACHUGH@ RTP.PES.COM

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Session XVII
P^2 Initiatives

Session Chairpersons:

Mr. Dennis Kirsch, HQ AETC/CEVQ
Ms. Teresa Green, HQ AFCEE/EQT

Development of Environmentally-Compliant Surface Treatments

Tammy Metroke, Robert Parkhill, and Ed Knobbe*, Department of Chemistry,
Oklahoma State University, Stillwater, OK 74078
Tel (405)744-9994 E-mail knobbe@okway.okstate.edu

Abstract

Stricter environmental regulations have banned the use of chromate-based treatments as a part of corrosion inhibition packages for aluminum-skinned aircraft. This, combined with the push for increased aircraft lifetimes, has lead to the need for development of environmentally-compliant coatings. The sol-gel method is being investigated as an environmentally-compliant alternative for chromate-based conversion coatings. Thin films prepared via the sol-gel method are water-based with low VOC emissions, dense, and chemically inert. Results of corrosion resistance tests will be discussed.

Introduction

Recently, stricter environmental regulations have mandated that chromate-based treatments be removed from corrosion inhibition packages for aluminum-skinned aircraft. Replacement coating systems must be capable of satisfying the need for dramatically extended aircraft lifetimes, must be compatible with present and future environmental requirements, and must be easily integrated into the current primer/topcoat paint systems.

Since the preparation of the first silicon alkoxide in 1846, the sol-gel method has emerged as a versatile method for preparing a host of oxide materials[1]. The sol-gel method consists of simultaneous hydrolysis and condensation reactions originating with alkoxide precursors to form a polymeric network of micro- or nanoporous glass as shown in equations 1 and 2.

(1) Hydrolysis $Si(OR)_4 + 4H_2O \rightarrow Si(OH)_4 + 4ROH$

(2) Condensation $Si(OH)_4 + Si(OH)_4 \rightarrow (OH)_3Si\text{-}O\text{-}Si(OH)_3 + H_2O$

Prior to gelation, the sol is ideal for preparing thin films by common processes, including dipping, spinning, or spraying[1,2]. Sol-gel materials are candidates for use in passivating film applications, as it is possible to form glassy, highly adherent, chemically inert films on metal substrates at room temperature.

Ormosils are hybrid organic-inorganic materials composed of intimately mixed polymer systems. Ormosil films are of interest because they blend the mechanical and chemical characteristics of the comprising networks. The inorganic regions impart durability, scratch resistance, and improved adhesion to the aluminum alloy substrates, while the organic regions impart increased flexibility, density, and functional compatibility with organic polymer paint systems. Hybrid films may be tailored to have exceptional durability and adhesion, while providing a dense, flexible barrier to permeation of water and corrosion initiators.

In the present study, sol-gel derived thin films have been investigated for use as environmentally-compliant alternatives to chromate-based conversion coatings. The results of this study indicate that sol-gel derived coatings are promising candidates for environmentally-compliant alternatives for the chromate-based conversion coatings in use today.

Experimental

Materials and Reagents: Substrates consisted of aluminum 2024-T3 coupons which were polished with 400 and 600 grit silicon carbide sand paper followed by cleaning in an ultrasonic bath using isopropanol and hexane solvents. Tetraethoxysilane (TEOS) and 3-glycidoxypropyltrimethoxysilane (GPTMS) were used as received from Aldrich. Surfactants were incorporated by direct dissolution into the aqueous sol. Nitric acid was used to catalyze the hydrolysis reaction.

Sol-Gel Thin Film Preparations: Preparation of ormosil solutions may be summarized as follows: 11.1 ml of TEOS were placed in a beaker with 3.6 ml of acidified water. The resultant two-phase solution was vigorously stirred to induce mixing and initiate hydrolysis. The sol was stirred for approximately 1 hour, followed by addition of GPTMS to the clear, single phase solution. Surfactants were added in a drop-wise manner until the desired concentrations were obtained.

Coating and Curing Methods: Aluminum 2024-T3 substrates were dipped into precursor sols using single dip step using a dwell time of 10 seconds in the coating sol. The withdrawal speed was 10 cm/s into room temperature air. After dipping, the samples were cured overnight in a 60 °C oven, followed by 24 hours in a 120 °C oven. After heat treatment, the samples were allowed to cool to room temperature.

Paint Systems: [Urethane primer/urethane topcoat], [epoxy primer/urethane topcoat], and self priming topcoat were used as primer/topcoat systems in this study.

Corrosion Resistance Tests: Ormosil-coated test coupons were placed in a 5% salt spray solution for 1000 hours. After removal from the salt fog chamber, the samples were rinsed with distilled water to remove any residues.

Results

Corrosion Resistance Tests

Protective properties of hybrid sol-gel films were determined in relation to 2024-T3 aluminum coupons which were (a) untreated and pretreated with (b)phosphoric acid, (c) alodine, and (d) phosphoric acid and alodine. Film performance was studied as a function of surface treatments.

Epoxy Primer/ Urethane Topcoat System

Figure 1 shows the results of the 1000 hour salt spray corrosion resistance test for aluminum samples treated as follows: (a) bare aluminum, (b) phosphoric acid pretreatment, (c) alodine pretreatment, (d) phosphoric acid wash followed by alodine pretreatment, and (e) sol-gel coating. Moderate corrosion in the scribe mark and blistering which extends 1/16 to 1/8" from the center of the scribe mark is observed on the bare aluminum panel (Figure 1a). While decreasing the extent of blistering observed, phosphoric acid or alodine pretreatment resulted in increased concentrations of corrosion

within the scribe mark, indicating degradation in the corrosion resistance performance of the primer/ topcoat system (Figures 1b and 1c). Pretreatment with both phosphoric acid and alodine decreases the amount of blistering observed (Figure 1d). Treatment with the sol-gel coating lead to a significant improvement in the corrosion resistance behavior of the samples tested, as only light to moderate corrosion in the scribe marks and no blistering was observed (Figure 1e).

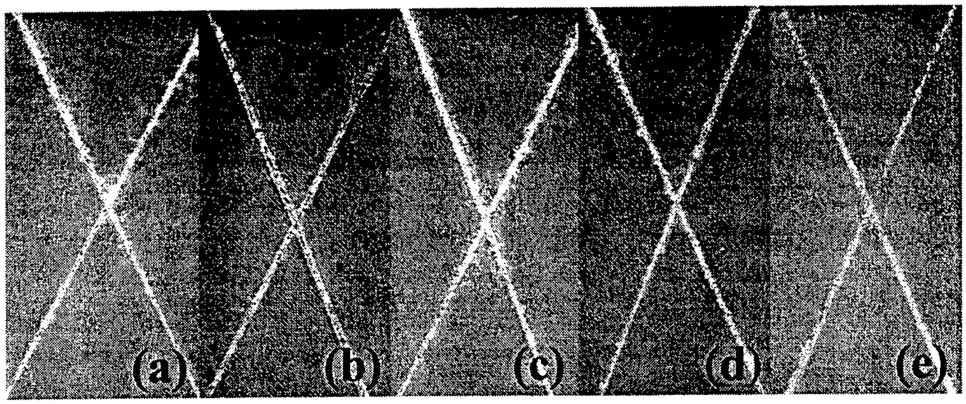

Figure 1: Results of corrosion resistance test for aluminum coupons which have been treated, prior to application of epoxy primer/ urethane topcoat system, as follows: (a) untreated, (b) phosphoric acid pretreatment, (c) alodine pretreatment, (d) phosphoric acid and alodine pretreatments, and (e) sol-gel coating.

<u>Urethane Primer/ Urethane Topcoat System</u>

Figure 2 shows the results of 1000 hour salt spray corrosion resistance tests for the urethane primer/ urethane topcoat system. In the untreated sample, extremely heavy corrosion and blistering are observed (Figure 2a). Addition of phosphoric acid decreases the amount of corrosion in the scribe mark, but dramatically increases the amount of blistering observed (Figure 2b). Alodine pretreatment, significantly reduces the extent of corrosion and no blistering is observed (Figure 2c). The moderate corrosion and blistering observed in Figure 2d indicate that dual pretreatments with phosphoric acid and alodine improve the corrosion resistance characteristics compared to bare aluminum. However, when used in conjunction with the urethane primer/urethane topcoat system, phosphoric acid pretreatment appears to degrade the performance of the alodine pretreatment. The appearance of the coupon treated with the sol-gel coating is comparable to that of the coupon treated with alodine: light to moderate corrosion is observed in the scribe mark and only slight blistering is observed (Figure 2e).

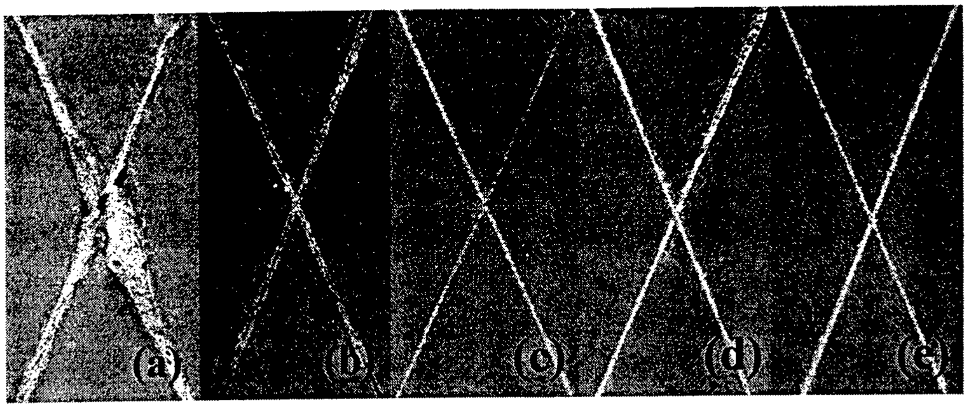

Figure 2: Results of corrosion resistance test for aluminum coupons which have been treated, prior to application of urethane primer/ urethane topcoat system, as follows: (a) untreated, (b) phosphoric acid pretreatment, (c) alodine pretreatment, (d) phosphoric acid and alodine pretreatments, and (e) sol-gel coating.

Self-Priming Topcoat System

Compared to the epoxy and urethane primer/topcoat systems, the self-priming topcoat system appears to provide minimal corrosion resistance as indicated by the extremely heavy corrosion and paint peeling observed in Figure 3a. Pretreatment with either phosphoric acid or alodine appear to improve the corrosion resistance slightly, though heavy corrosion and blistering/peeling is observed on the bare aluminum surface (Figure 3b and 3c). Combination of phosphoric acid and alodine pretreatment improves the passivation effect, as indicated by a reduction in the concentration of corrosion and blistering (Figure 3d). Use of the sol-gel coating (Figure 3e) shows dramatic improvements in the corrosion resistance behavior of the coupons tested, as blistering is not observed and corrosion is moderate and within the scribe mark.

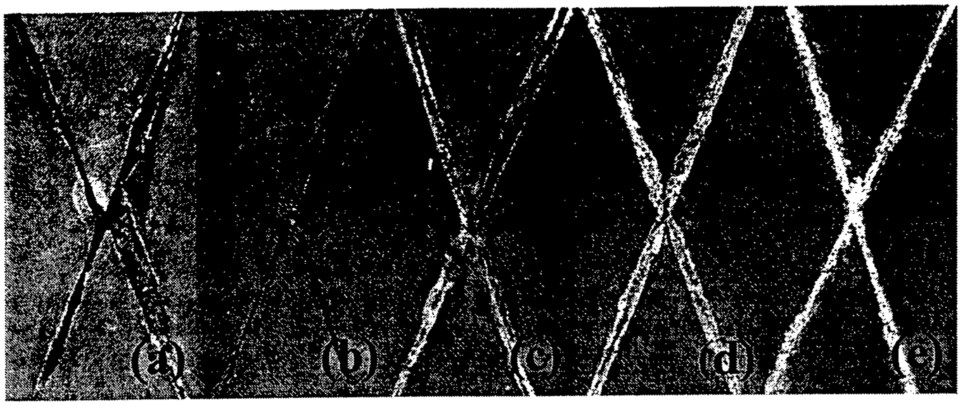

Figure 3: Results of corrosion resistance test for aluminum coupons which have been treated, prior to application of self-priming topcoat system, as follows: (a) untreated, (b) phosphoric acid pretreatment, (c) alodine pretreatment, (d) phosphoric acid and alodine pretreatments, and (e) sol-gel coating.

Discussion

Chemical conversion coatings are used to enhance the corrosion resistance of a surface through forming a barrier which inhibits the penetration of corrosion initiating species and increasing the paint adhesion[3]. In this study, the effectiveness of sol-gel coatings was compared to the effectiveness of three primer topcoat systems and three surface pretreatment procedures which are currently in use for the passivation of aluminum skinned aircraft. Prior to any surface pretreatment, the epoxy, urethane, and self-priming topcoat systems showed minimal corrosion resistance capabilites. In all three systems, use of the chromate-based alodine pretreatment lead to improvements in the corrosion resistance abilities of the primer/topcoat system. Phosphoric acid pretreatment increased the tendency for blistering/peeling. Combination of phosphoric acid and alodine pretreatments generally improved the corrosion resistance behavior of the paint systems by confining corrosion to the scribe marks and minimizing the amount of blistering which was observed. In all three primer/ topcoat systems, use of a sol-gel coating led to significant increases in the corrosion resistance behavior of the paint system.

Thin films prepared using the sol-gel method are characteristically chemically inert and impenetrable by water and other corrosion initiating ions. Because the degree of secondary barrier action depends on the continuity, compactness, and stability of the corrosion product layer[3], variation in the chemical composition of the ormosil sol leads to variation in the properties of the resulting thin film. Sol-gel derived thin films are promising, environmentally-compliant alternatives to chromate-based conversion coatings presently used for passivation of aircraft aluminum alloys.

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AN EVER CHANGING POLLUTION PREVENTION PICTURE (#152)

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INTRODUCTION

Fort Lewis Military Reservation is an 86,176 acre Army installation located 35 miles south of Seattle and 7 miles northeast of Olympia. Various military and non-military organizations at Fort Lewis perform services and functions, which require the use of hazardous substances and generate hazardous waste. These activities are vital to the field readiness of military troops and support the day-to-day functions of Fort Lewis as a community. Services include the maintenance of over 4,500 Fort Lewis buildings and infrastructure such as roads and utilities, operation and maintenance of over 3,000 vehicles and nearly 1,500 pieces of equipment including aircraft, weapons systems, power generators, and communications equipment. A major hospital, several medical and dental clinics, printing and graphics facilities, materials storage warehouses and crafts shops also operate on Fort Lewis.

Fort Lewis, the largest employer in Pierce County, has a combined military, civilian and retiree payroll of almost $1 billion. Fort Lewis' force structure includes I Corps Headquarters, which commands all Forces Command units at Fort Lewis. I Corps Headquarters conducts planning and also acts as a liaison with other active and reserve component units in the continental United States and active duty units located around the Pacific Rim and in Hawaii. Fort Lewis directly supports the Yakima Training Center and six Base Realignment and Closure installations in Washington and California. The installation also serves occasional users from other U.S. armed services and units from allied nations.

PROGRAM OVERVIEW

The Fort Lewis Pollution Prevention (P^2) Program is designed to reduce the volume of hazardous materials used and hazardous waste produced on the installation, as well as reduce energy consumption, air emissions, and solid wastes. In FY 96 and 97, the program saved more than $2 million by implementing innovative alternatives to standard processes.

The P^2 Program is an on-going, comprehensive examination of operations on the installation. The primary goal of the P^2 Program is to minimize types and volumes of hazardous materials used and hazardous waste generated in these waste streams, by identifying low cost, commercial-off-the-shelf (COTS) options that make sense, save money, and are in accordance with the law.

The Fort Lewis Pollution Prevention Program operates under these assumptions:

1) Waste is an indicator of inefficiency, which is undesirable;
2) There are numerous waste issues, including air emissions, indoor air quality, non-hazardous waste, energy, hazardous waste, injuries, loss of capacity (land, water, air, ecosystems), and resource waste (money spent on the wrong thing);
3) We are capable of identifying and measuring waste; and
4) We are capable of taking action to reduce waste.

By following these guidelines, the P^2 program reduces operating costs, increases training readiness, protects public health and the environment, and reduces the risk of civil and criminal liability.

Pollution Prevention Plan

The Fort Lewis Pollution Prevention Plan provides a specific plan and implementation schedule for the reduction of hazardous substance use and hazardous waste generation through selected pollution prevention opportunities. A formalized five-year pollution prevention plan was completed in September of 1992, with 1991 as the baseline year.

A formal five-year update was submitted to Washington State Department of Ecology in September 1997. Fort Lewis worked with regulators to ensure that the new plan meets requirements of the state, Department of Defense, and Executive Order 12856. The pollution prevention plan update will have baseline years of 1992, 1994, and 1996 and will be kept current through submission of annual progress reports due September of every year.

Inter-Related Facility Status

To reduce reporting burdens on Fort Lewis and its subinstallations, Fort Lewis applied for and was granted inter-related facility status in May of 1996. This status allows Fort Lewis and its subinstallations to prepare only one plan, prepare only one annual report, and pay only one hazardous waste generator's fee. Thus, inter-related facility status saves Fort Lewis both time and money.

TECHNIQUES AND INNOVATIONS

Pollution prevention projects are identified and evaluated on a yearly basis by utilizing the following steps. Data is collected from the hazardous waste, EPCRA, air and solid waste programs. In each media, the data is prioritized from largest to smallest volumes with most toxic chemicals at the top regardless of volume. The total volume is calculated and 95% of that is targeted for pollution prevention. In many cases, the top HW streams and the top HM used are related. By selecting initiatives that target specific chemicals, it is possible to realize reductions in all media. Fort Lewis follows the EPA waste management hierarchy when evaluating pollution prevention initiatives. Source reduction projects are our first choice, followed by projects that encourage recycling or reuse. In some cases, treatment on site is appropriate. When technology is not available, wastes are disposed through DRMO and other TSDFs.

Reducing the number and types of hazardous materials used and reducing the volume of waste generated provides money that Fort Lewis can use for other facility requirements. Many pollution prevention projects save money by avoiding other costs such as fines and penalties, utilities cost, and labor cost. Pollution prevention projects can be categorized into the following types of projects: Low cost, commercial off the shelf (COTS) technology (best management practices); equipment changes; service changes; process changes; and policy changes. Currently, Fort Lewis is working to validate the implemented projects to show benefit and cost savings realized. Table 1 summarizes a few of our validated implemented projects, benefits and quantifiable cost savings.

GOALS AND PROGRESS

Overall P^2 performance goals for Fort Lewis were established. The goals are listed below:

Hazardous Substance Use Reduction Goals	Hazardous Waste Reduction Goals	Recycle/Reuse Goals	On-Site Waste Treatment Goals
50%	20%	5% of total waste volume	5% of total waste volume

Many factors impact progress toward performance goals. Changing regulations affect what is considered hazardous. Changes in troop strength and vehicle types affect volumes of hazardous materials used and hazardous waste generated. Notable changes for Fort Lewis include the shift from a light

infantry division with no armor in 1991, to a heavy mechanized/armored brigade + in 1995. This included adding approximately 500 tracked vehicles, with up to 500 gallons of fuel each, and associated maintenance programs to the management requirements of the pollution prevention program. The objectives and direction of the pollution prevention program must be able to respond to and answer these challenges as they occur.

Hazardous Substance Use Reduction: In 1994, Fort Lewis began compliance with Executive Order 12856. This executive order requires federal facility to comply with the requirements of the Emergency Planning and Community Right To Know Act and Federal Pollution Prevention Act of 1990. Compliance with Executive Order 12856 has provided better control over the hazardous substances on Fort Lewis. The post prepares weekly hazardous substance inventories submits quarterly reports on activities that use hazardous substances and generate hazardous waste. These inventories are managed using a Microsoft Access database which tracks storage locations and is used to prepare Tier II and Form R reports. In addition, the database can be linked to GIS to prepare maps identifying storage and use locations of Extremely Hazardous Substances, Tier II chemicals, and TRI chemicals.

The EPCRA database was used to summarize the quantities used of TRI Chemicals, 33-50 chemicals, Montreal Protocol Chemicals and restricted use chemicals from 1994-1997. Reduction goals of 50% were met in all but TRI chemical usage.

	50% Goal	**1994**	**1995**	**1996**	**1997**
TRI Chemical Usage (pounds)	279,560	559,119	960,396	341,315	308,541
33-50 Chemical Usage (pounds)	91,311	182,622	404,979	78,035	87959
Restricted Chemical Usage (pounds)	81,842	163,684	97,246	45,365	31,550
Montreal Protocol Chemical Usage (pounds)	59,698	119,397	50,828	9,376	9,987

Hazardous Waste Reduction: In 1996, 22,484 pounds of EHW and 1,143,752 pounds of DW were generated. 40% of the DW waste generated in 1996 was from a contract to clean out all oil-water separators on the installation and from incinerator ash that did not pass the TCLP. The incinerator came on line in 1996 for test burns. Operators are still determining the optimum operating conditions. 689,235 pounds of HW was from ongoing processes. 96.7% (666,751 pounds) was DW and 3.3% (22,484 pounds) was EHW. The EHW waste generated in 1995 is 79% less than EHW generated in 1991. DW increased by 85%. However, there were two regulatory changes during the five years covered by this plan that regulate more waste as hazardous.

In 1991, Fort Lewis generated 153,885 pounds of EHW and 297,675 pounds of DW. EHW has decreased by 85% from the 1991 baseline year. Since 1995, the EHW decreased by 30.5% or 9883 pounds. DW increased by 123% from the 1991 baseline year. Since 1995, DW increased by 21%. This data has not been normalized.

Hazardous Waste to be Recycled: Five waste streams are currently being recycled at Fort Lewis. In 1991, none of these waste streams were being recycled. In 1994, an off-site recycling program was implemented for Antifreeze. In 1996, 99% of all antifreeze on Fort Lewis was recycled through this program. Safety Kleen also began a recycling program for solvents managed from Fort Lewis. The recycling credits for Safety Kleen has increased from 90% in 1994 to 95% in 1996. Two additional waste streams, medical solvents (ethanol and xylene) are now being recycled on-site. This program was implemented in late 1996. A total of 622 pounds of this solvent was recycled in the last quarter of 1996. While the volumes are relatively low, substantial cost savings is being realized. Foramlin, a tissue preservative used at the hospital, is being filtered and reused, thus avoiding an additional 1091 pounds being managed as HW.

Antifreeze is currently being managed as a non-hazardous waste. The total volume of waste generated in 1996 (minus the 40% incinerator and oil-water separator sludge) was 1,658,772 pounds. Waste currently being recycled is 149, 690 pounds. This is 9% of the total waste, which exceeds the established goal of 5%.

Hazardous Waste to be Treated: In 1991, none of the hazardous waste was being treated on site. In 1995, formaldehyde and formalin solution was being treated manually prior to discharge to the sanitary sewer system. In 1996, equipment was purchased to treat the formaldehyde solution automatically. 87% of this waste stream was treated in 1996.

Equipment to remove silver from photographic fixer was purchased and implemented at the Madigan Army Medical Center. 41,292 pounds of fixer was treated to remove silver, neutralized, and discharged to the federally owned treatment plant. This equipment was implemented in late 1996. 53% of the fixers managed at Fort Lewis underwent the silver recovery process.

Formaldehyde and photographic fixers are managed as HW. A total of 47,077 pounds was treated on site. This is 6.8% of the total HW and 3% of the total waste managed at Fort Lewis. The established goals for treating HW were 5%.

CONCLUSIONS

The pollution prevention program is designed to reduce volumes of hazardous material used and hazardous waste produced on the installation. Reductions are achieved by establishing goals, evaluating data annually, identifying and implementing projects that reduce usage and waste generation, and measuring progress towards the goals. Many factors affect reductions and impact progress towards performance goals. The objective and direction of the program must be able to respond to and address those factors as those occur.

Table 1: Validated Pollution Prevention Projects, Fort Lewis, WA.

	P2 Project	Year	Type of Project	Capitol Investment	Annual Cost Savings	Benefits
1	Silver Recovery Project-MAMC	1996	On-Site Recycling	$19,762	$15,000	Waste Reduction: 80,000 pounds 50 pounds of Silver Reclaimed annually
2	Formaldehyde Filtration & Treatment-MAMC	1996	On-Site Treatment	$6,041	$12,193	HM (TRI) Reduction: 3140 pounds Treatment On-Site: 3140 pounds
3	Medical Solvent Recycling	1997	On-Site Recycling & On-Site Reuse	$11,946	$12,269	Waste Reduction: 2408 pounds HM Use Reduction: 3140 pounds
4	Weapons Cleaning Project	1996	Source Reduction: HM Substitution & Improved Processes and Procedures	$125,612	$2,500,000	HM Use Reduction: 28,000 pounds 85% reduction in Troop Labor Standardization of Process and Materials
5	Parts Washers with Filters in Vehicle Maintenance Applications	1996	Source Reduction: HM Substitution & Improved Processes and Procedures	$78,660	$10,165	Waste Reduction: 3952 pounds HM Use Reduction: 4888 pounds Reduction in toxicity Standardization of Process and Materials
6	Paint Gun Cleaning in DOL	1996	Source Reduction: Improved Equipment & Procedures	$3,955	$726	Waste Reduction: 339 pounds HM Use Reduction: 450 pounds
7	Paint Solvent Recycling at DOL	1995	On-Site Recycling & On-Site Reuse	$7,090	$6,795	Waste Reduction: 3053 pounds HM Use Reduction: 3000 pounds
8	Risograph at DPCA Marketing	1996	Source Reduction: Improved Process	$29,813	$7,861	Waste Reduction: 1,715 pounds HM Use Reduction: 80% Reduction 50% increase in Productivity without increase in manpower
9	Aqueous Parts Washers	1995	Source Reduction: HM Substitution & Improved Processes and Procedures	$52,626	$19,500	NPDES discharge limits not exceeded Decrease in labor cleaning large parts Reduction in toxicity of cleaners
10	TASC Digital Photography	1997	Source Reduction: Hazardous Material and Waste Elimination through Improved Equipment & Procedures	$156,700	$1,255,200	Reduction of photographic chemicals collectively valued at $45,000; Reduction of silver-containing waste Reduction in Troop Labor
11	PCS Soil Cleanup & reuse	1997	On-Site Treatment & On-Site Reuse	$49,427	$230,920	500 Cubic yards of soil treated and reused as fill
12	Chlorine gas substitution at Fort Lewis WTP	1996	Source Reduction & Risk reduction via Hazardous Material Substitution	$3,120	$5186	Replaces a TRI reportable chemical Reduction in Risk Improves Safety of surrounding community

DECONSTRUCTION in the DEPARTMENT of the ARMY

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Aberdeen Proving Ground (APG) is piloting a deconstruction project to return valuable building materials and other useful items to the community, rather than sending them to a landfill. Deconstruction is the dismantling of a building in the opposite order in which it was built so that its component parts can be segregated for reuse. Two buildings will be deconstructed in 1998 as part of the pilot project.

Federal and Army requirements regarding pollution prevention and recycling have helped generate a renewed interest in deconstruction within the Army. Deconstruction is not a new idea for APG, however. From the 1960s to the 1980s, APG routinely sold components of buildings and buildings in their entirety to members of the community. Unfortunately, in the mid-1980s, an individual was injured while dismantling a building, so the project was halted out of concern for public safety. In recent years, approximately one-fifth of all non-hazardous solid wastes at APG comes from construction and demolition debris.

The Directorate of Safety, Health and Environment (DSHE) has modeled the APG deconstruction pilot project after other successful programs at Fort Ord in Marina, CA, Fort McCoy in Wisconsin, and Fort Knox in Kentucky. The APG Deconstruction Team consists of DSHE, the Directorate of Public Works, and the Testing and Evaluation Command Legal Office.

The greatest benefit to deconstruction is improved community relations. Returning taxpayer-purchased resources to the community is the greatest reward. The second benefit is the reduction in wastes. Fort McCoy boasts an 85 percent reduction in landfilled wastes from their deconstruction effort. The third benefit is the cost savings. The types of structures APG plans to deconstruct currently cost approximately fifteen dollars per square foot to demolish in the traditional fashion. Based on the experiences of Forts McCoy and Knox, APG hopes to reduce that cost by up to 86 percent through deconstruction. For the two buildings available for deconstruction through this pilot project, savings of up to $77,000 are possible.

The three major challenges to this project have been the coordination, learning the requirements, and finding bidders. Conducting a pilot project can be fun and exciting, but it can also be difficult and frustrating without the right recipe of team members. Relying heavily on the experiences of our counterparts at the other installations, APG pulled in the appropriate personnel for its internal team. This group meets every two weeks to discuss the status of the deconstruction and demolition projects.

Early on, team members compiled their program requirements, to include site safety, environmental and historical review, and legal parameters. These requirements guided the development of the contract - - and the foundation of the project actually rests on these requirements. For instance, the removal of all asbestos is the responsibility of the post. Another example of a program requirement is that the purchaser must follow OSHA requirements for demolition site safety.

Quotes were solicited by phone to specific vendors of salvaged wood in the beginning of June. During the second week of June, a request for quotes was published in local and state-wide newspapers, with the last publication date being June 27. The Directorate of Contracting sends any interested parties the quote package, including the statement of work and draft contract. Before the final quotes are submitted, one site visit will be scheduled for all interested parties. APG expects to accept and award the contract by the end of July, depending on any negotiations that may take place between the installation and any bidders. The deconstruction will likely begin in early August and be completed within 60 days. Thus far, we have received four calls for further information from potential bidders.

If the pilot project is successful, APG will propose to sell more of the thirteen other buildings eligible for deconstruction in order to return these valuable resources to the community, reduce the impact of demolition on our landfills, and save money.

Session XVIII
P^2 In Painting Operations

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Performance Testing of Durable, Cleanable Aircraft Coatings

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Abstract: The Air Force Research Laboratory (AFRL) and its contractors, SAIC and Battelle are currently assessing the durability and cleanability of new aircraft coatings submitted by coatings vendors. Over 75% of the hazardous wastes generated by the Air Force are directly related to the painting/depainting process, and a large part of this topcoat repainting occurs at the field level. Low gloss polyurethane topcoats are difficult to clean due to surface roughness, and the polyurethane based topcoat fades and chalks due to ultraviolet (UV) exposure from the sun. These two effects and their combination discolors the topcoat, resulting in the need for repainting. The Air Force prepared a detailed list of performance requirements based upon user input emphasizing cleanability and weatherability. The laboratory tests developed by SAIC and Battelle will measure conformance with these requirements. Publicized breakthroughs in industrial coatings technologies showed promise if they could be modified for low gloss military applications. AFRL solicited coatings manufacturers, researchers, and formulators for innovative coatings that meet the prescribed requirements. These vendors submitted wet samples and coated aluminum panels for testing. The submitted samples are undergoing extensive testing to determine general performance properties such as water and solvent resistance, flexibility, adhesion, surface hardness, abrasion resistance, environmental exposure, and cure characteristics. In addition, the test regimen will examine the effects on the performance properties of multiple stresses from temperature extremes, cyclic loads, rapid decompression, and UV exposures. The first round of initial screening tests is complete and several candidates show promise of improved hardness and cure time. Following the complete array of laboratory tests, SAIC and Battelle will determine which coatings show promise as potential replacements for existing formulations and make recommendations to AFRL on fielding these replacements.

INTRODUCTION

The most difficult environmental problems associated with aircraft maintenance operations come from the use of coatings to protect the aircraft from weathering and corrosion. These coatings and the solvents used to apply them contain hazardous materials that are harmful to painters and the environment. Three quarters of all Air Force hazardous waste is due to the application and removal of aircraft coatings. Of the 438,000 lbs. of volatile organic compound (VOC) generated each year at the Air Force's depots, approximately 220,000 lbs. are due to the paint application process. The Air Force also estimates that field-level aircraft painting generates 700,000 lbs. of VOCs annually[1]. Department of Defense aircraft maintenance operations have had limited success in identifying alternative low-VOC and aqueous coatings that do not require the use of EPA 17 chemicals for formulation or application. Military aircraft have a low gloss (<5 gloss units) requirement that requires high pigment loading in the paint. The high pigment loading results in a physically rough surface that diffuses light, resulting in low gloss. This rough surface holds dirt and other contaminants (oils, hydraulic fluids), making cleaning difficult. In addition, the relatively low resin content is extremely sensitive to ultraviolet degradation from the sun. This results in chalking and discoloration, and when combined with poor cleanability is forcing the field units to touch up and repaint at an environmentally unacceptable frequency. Environmentally compliant coatings are offered commercially, but the coatings that the Air Force has evaluated do not meet the performance requirements for military aircraft. As a result, DoD installations must spend more time

reapplying and repairing aircraft coatings, which can increase waste generation rates and affect operational readiness. Thus, the Air Force seeks to identify environmentally preferable aircraft coatings that are significantly more durable and cleanable than currently used aircraft topcoats.

PERFORMANCE REQUIREMENTS AND PROJECT DESIGN

Before conducting performance testing on aircraft coatings, AFRL first had to define the requirements for an effective coating. Engineers at the AFRL Materials and Manufacturing Directorate solicited inputs from the F-15 System Program Office, the Warner Robins Air Logistics Center, and Air Combat Command in preparing these requirements. Common inputs received were improved hardness of the coating to resist scuffs and scrapes during ground maintenance and reduced cure time for improved turnaround. An effective aircraft coating must meet the environmental requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) rule[2] for aerospace manufacturing and rework facilities, which stipulated that all uncontrolled topcoats must not exceed 420 g/l in volatile organic compounds or organic HAPs. In addition, the Air Force has committed to the reduction of the usage of the EPA 17 Industrial Toxic Chemicals[3,4], several of which are often used in aircraft coating formulations[5]. These regulations formed the basis for the environmental component of the requirements for a durable, cleanable aircraft coating. Therefore, an acceptable coating must comply with the NESHAPs rule and contain no EPA 17 chemicals in its applied form.

The limitations on the constituents and concentrations of chemicals in the coatings were combined with a list of extremely rigorous performance requirements, which AFRL selected to define the durability and cleanability of the coating. These performance requirements are presented in Figure 1 below.

General Properties	*Wet Properties*	*Film Properties*
weathering resistance	pot life	flexibility
cleanability with aircraft cleaners	drying time	adhesion
fluid resistance	viscosity	rain erosion resistance
mar resistance	shelf-life	color
humidity resistance	freeze-thaw stability	gloss
heat resistance		infrared reflectance
abrasion resistance		

Figure 1. Performance Requirements for Aircraft Coatings

AFRL assembled all these requirements into a *Durable, Cleanable Coatings Requirements Document*[6], which was distributed to coatings manufacturers and formulators in July of 1997 to encourage these vendors to prepare a coating sample that could meet these requirements. To assist in guiding materials development, the requirements document was broken into two sections: general requirements and desired properties. Conformance to the general requirements were of greatest importance: specimen preparation, environmental compliance, compatibility with existing painting equipment and situations, and environmental resistance. Environmental resistance required that candidate topcoat candidates meet artificial weathering (Xenon and Carbon Arc, UV Condensate) and cleanability exposures with minimal color change ($\Delta E < 0.3$). AFRL provided the desired properties to allow vendors to "trade off" other coating properties for the more important durability and cleanability requirements.

After AFRL distributed the *Coatings Requirements Document* to interested vendors, they conducted a meeting at Wright-Patterson AFB to answer any questions and to explain the purpose and schedule for the durable, cleanable coating project. AFRL informed the vendors that it was seeking samples of

coatings that could meet or exceed the properties described in the *Coatings Requirements Document* and that it would conduct testing on these samples to determine if the coatings met the requirements. AFRL contracted with SAIC and Battelle to conduct performance tests on the coatings submitted by vendors.

The schedule for the evaluation of coatings submitted by vendors is shown in Figure 2 below. After AFRL held the meeting with coatings vendors, Battelle developed the test plans and prepared the sample submittal procedures. Battelle sent these procedures to the vendors along with an invitation to submit coatings samples for evaluation. Battelle received the coating samples and conducted the initial screening tests using the tests outlined in the initial screening test plan. Battelle will conduct full laboratory tests of these samples and prepare an interim test report based on the first round of testing. Battelle will repeat the testing process, after informing the coatings vendors of the results of the first round of testing. This will allow vendors to modify their formulations against deficiencies identified during testing and attempt to improve their performance. After completing a second round of testing, Battelle will prepare a final test report that will summarize the results of the overall effort.

Activity	*Date*
Project Start	July 1997
Test Plan Development	October 1997 to January 1998
Coating Sample Submission I	January 1998
Initial Screening Tests I	February 1998 to April 1998
Full Laboratory Tests I	May 1998 to August 1998
Interim Test Report	October 1998
Coating Sample Submission II	October 1998
Initial Screening Tests II	October 1998 to December 1998
Full Laboratory Tests II	December 1998 to March 1999
Final Test Report	April 1999

Figure 2. Schedule for the Evaluation of Vendor-Submitted Coatings

SAMPLE SUBMITTAL

AFRL invited coatings vendors to prepare samples that would meet or exceed the specifications described in the *Coatings Requirements Document*. The procedure for sample submittal called for a wet sample of the coating and a set of coated aluminum panels, with the coating applied over a chromate conversion coating (MIL-C-5541) and standard Air Force primer (MIL-P-23377G, Type I, Class C). The coated panels were used only for the initial screening tests [see Initial Screening Tests below]. Battelle used the wet samples to prepare coated panels for the full laboratory tests. Battelle also prepared the panels with a chromate conversion coating and standard primer, which is typical for Air Force aircraft.

INITIAL SCREENING TESTS

In the screening tests, Battelle evaluated coated aluminum panels supplied by the vendors and the cure characteristics of wet samples as applied to aluminum panels in the laboratory. Battelle designed the initial screening tests to identify processability, durability and cleanability deficiencies. The cure profile will determine if a coating will provide the desired level of water resistance and durability after a 48-hour cure. For the initial screening tests, Battelle conducted the tests listed in Figure 3 below.

Battelle developed a cyclic temperature test and rapid decompression test to generate the types of coating failures (microcracking, blistering, and delamination) observed in operational aircraft. The repeated washing test exposed painted specimens to repeated scrubbing using a cleaning pad and cleaner used in

combined stresses on the coatings. Battelle will subject coated panels to another regimen of multiple stresses that includes humidity resistance, UV-B exposure, and low temperature cyclic loading. Following this series of stresses, Battelle will evaluate the panels for color and gloss changes, mar, hardness, conical mandrel flexibility, low temperature GE impact, and any visible surface defects, such as cracking or blistering.

DESIRABILITY ANALYSIS

To compare the performance of different coatings objectively, AFRL and Battelle devised a method to evaluate the test results for different tests for each coating. This method assigns a measure of utility (desirability value) to each property and allows the assignment of relative importance for each property measured. The desirability values to be used in this program are based on the extensive information gathered during the "Now-Term" Program that Battelle conducted for the Air Force[7]. Some of the parameters have been updated to reflect the more stringent desired properties for the durable, cleanable coating sought in this project as defined in the *Coatings Requirements Document.*

For each property, Battelle prepared a graph of the objective measurement of the property, as determined by laboratory testing, versus the desirability of the property, expressed on a scale from 0 to 1. For this desirability value, d=0 corresponds to a level of the property that would make the coating useless, and d=1 corresponds to a property level which cannot be improved upon. Intermediate levels of "d" correspond to intermediate levels of coating utility. After all of these identified properties are associated with a desirability curve, it is possible to obtain an average or composite desirability called "D" which is an overall measure of coating functionality and can be thought of as a property balance parameter as follows:

$$D = \sqrt[n]{d_1 \bullet d_2 \bullet d_3 \ldots d_n}$$

D is generally the weighted geometric mean so that D will also range between 0 and 1. Note that if any single property gives a zero desirability, D will also be zero. This reflects the fact that should a single property be unacceptable, D will equal 0 and the coating will be rejected. However, for a comparative study such as this project, it is important to see degrees of differences between coatings. Therefore, instead of assigning an unacceptable property a zero value, Battelle will substitute a value of 0.01. This rates the value of the property very low, but results in an overall desirability that can be rank-ordered among the coatings tested.

RESULTS

After conducting the initial screening tests, Battelle calculated individual desirability values for each property of each coating tested. From these individual desirability values, Battelle calculated a composite desirability "D". Figure 5 presents the results of these calculations. In the first round of initial screening tests, Battelle found that none of the coatings submitted by vendors equaled the composite desirability of the control coating after a 14-day cure. Two of the coatings did achieve performance superior to the control coating after a 2-day cure.

Battelle is currently evaluating the full laboratory performance of the submitted coatings. The results of these tests will be available in an interim report submitted to the Air Force in October, 1998. Following preparation of this interim report, Battelle will conduct another round of testing on samples submitted by coatings vendors.

2-Day Cure		14-Day Cure	
Coating	D	Coating	D
Coating 1	0.77	Control	0.54
Coating 2	0.77	Coating A	0.52
Control	0.75	Coating B	0.48
Coating 3	0.44	Coating C	0.47
Coating 4	0.41	Coating D	0.37
Coating 5	0.29	Coating E	0.27
Coating 6	0.19	Coating F	0.24
Coating 7	0.17	Coating G	0.24
Coating 8	0.09	Coating H	0.15

Figure 5. Composite Desirability of Submitted Coatings after the First Round of Initial Screening Tests[8]

CONCLUSIONS

The Air Force has developed a topcoat requirements document based upon depot, field, and command needs. SAIC and Battelle have developed a rigorous testing procedure that can be used to evaluate the performance of emerging, developmental aircraft coatings against Air Force requirements. The two round evaluation protocol developed by this team will allow paint vendors to reformulate their coatings and submit additional samples for testing after the first round of full laboratory tests are complete. Following the second round of testing, the Air Force should have more conclusive evidence of the availability of commercially available aircraft coatings that meet the desired performance requirements.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Air Force Research Laboratory Materials and Manufacturing Technology Directorate under the Special Advanced Studies for Pollution Prevention Contract, F33615-95-D-5615, Delivery Order 30.

ENDNOTES

[1] *Paint Stripping Equipment Reliability/Maintainability Improvement Problem Identification Study*, Southwest Research Institute, 5 April 1995.

[2] "National Emission Standards for Hazardous Air Pollutants for Source Categories: Aerospace Manufacturing and Rework Facilities". **60** *Federal Register* 45948-80.

[3] *Air Force Pollution Prevention Strategy*, 24 July 1995.

[4] Air Force Instruction 32-7080, *Pollution Prevention Program*, 12 May 1994.

[5] Typical aircraft coatings contain toluene, xylene, methyl ethyl ketone, and methyl isobutyl ketone as the solvents and thinners used to apply the coating.

[6] *Durable, Cleanable Coatings Requirements Document*, Air Force Research Laboratory, 1997.

[7] *Reliability and Maintainability Improvement, High Performance Aerospace Coating System Program,* Air Force Research Laboratory (AFRL/MLSS), contract number F-09603-90-D-2217-RZ02, 31 January 1998.

[8] Coatings are identified using different names for each column to preserve the anonymity of samples and vendors.

NOVEL CHROMIUM-FREE SURFACE PRETREATMENT PROCESS FOR CORROSION INHIBITION

by

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ABSTRACT

The need to eliminate hazardous materials and processes from pre-bond surface treatments has increased industrial interest in mechanical abrasion for cleaning, deoxidizing and roughening metallic adherends. The surface treatments described in this study use simpler and less hazardous means than traditional chemical etching to prepare metals for structural bonding and coating. The overall approach involved surface abrasion with both medium pressure water and abrasives and abrasive-free ultra high pressure water followed by treatment with aqueous organosilane solutions and chromium-free, waterborne primers. Both abrasive and non-abrasive pretreatments yielded excellent maintenance of paint adhesion and corrosion resistance under salt spray and GM Spec 9540P cyclic corrosion test conditions. Control adhesive pretreatments included the the P2 etch and phosphoric acid anodizing. The initial strength and durability of bonds prepared by standard and experimental pretreatment methods using bare and clad aluminum alloys of the 2XXX, 5XXX and 7XXX series and several commercial epoxy-based adhesives were measured by the tensile lap shear, floating roller peel, and wedge opening tests. The approach yielded adhesive bonds whose initial strength and durability in hostile environments met or exceeded those attained for adherends prepared by the control pre-bond surface treatments.

KEYWORDS:pretreatment, water jetting, adhesives, paint, abrasion, organosilanes, corrosion

1.0 INTRODUCTION

The combination of mechanical abrasion and organosilane coatings has been used as an alternative to traditional prebond surface treatments such the sulfo-chrome etch and chromic acid anodization. The techniques reported to date generally involve dry abrasive blasting followed by silane deposition or manual sanding in the presence of hydrolyzed organosilanes. An extension of this approach that provides simpler waste management and potentially more effective adhesion promotion is high-pressure blasting with partially hydrolyzed silane coupling agent solution and abrasive. The method has been found to be effective for rapidly removing surface contaminants and metal oxides and replacing them with a primed layer containing silicate boundary layers. The Primer Activated Surface Treatment (PAST) process incorporates the passivation of metal surfaces by the combination of mechanical abrasion from hydrosanding and interaction with hydrolyzed organosilane priming agents. The freshly exposed metal can be considered an activator for organosilane deposition and condensation. It has been demonstrated that organosilane films over ferrous and non-ferrous metals can inhibit corrosion and promote strong adhesion of paint and commercial adhesives.

Additional waste minimization was realized by increasing the water blasting pressure and removing solid abrasives such as aluminum oxide from the blast stream. The non-abrasive PAST (NA-PAST) process passivates metal surfaces by combining abrasive-free, mechanical abrasion from ultra high pressure water jetting and interaction with hydrolyzed organosilanes. This report describes the paint removal, corrosion test results and adhesion performance of non-ferrous alloys prepared by the NA-PAST process.

The objective was to develop an effective, easily applicable surface treatment for aluminum and titanium alloys to replace currently used prepaint methods that rely on toxic and corrosive chemicals such as chromate conversion coatings. The approach was to explore alternative methods of metal deoxidation and stabilization through abrasive-free waterjet abrasion and application of an organosilane pretreatment.

The report below is but a small subset of the actual testing which occurred during the initial study of organosilane chemistry. Due to page constraints, only the results of accelerated corrosion testing are presented. Cape Cod Research also performed an in-depth study of the chemical reactions between organosilanes and native aluminum substrates as well as performing outdoor weathering, salt spray resistance and chip/abrasion resistance testing. The reader is welcome to contact the author for more information on these test results as well as for a current status of production-scale testing of the organosilane formulations at the National Defense Center for Environmental Excellence.

2.0 EXPERIMENTAL

2.1 Abrasive-Free NA-PAST Pretreatment Process

The NA-PAST process consists of four steps:

The degreased metal substrates are first deoxidized by ultra-high pressure (30-50 ksi) water blasting.

The deoxidized surfaces are treated with proprietary blends of hydrolyzed organosilanes in aqueous solution (note: the organosilane can be applied simultaneously during the hydrosanding by injecting concentrated solutions in the blast stream or it can be applied in diluted form after hydrosanding).

3) The organosilane passivation coating is dried at 93°C (200°F) for one hour.
4) A chromate-free, waterborne corrosion inhibiting adhesive primer is applied.

2.2 Organosilane Solution Formulation

Preliminary surface passivating agent formulations were prepared by dissolving commercially available organosilanes such as 3-glycidoxypropyltrimethoxysilane (GLYMO) and 3-mercaptopropyltrimethoxysilane (MPTMOS) in deionized water at a concentration of 1 percent on a weight basis. The solutions were stirred at ambient temperature for a period of 45 minutes to one hour before applying to deoxidized metal substrates. Various additives including organic dyes, surfactants, acids, and other organosilanes were used in these formulations to alter such properties as hydrolysis rate, surface wetting, surface film coloration for visual quality determination, and solution stability.

The organosilanes were chosen for their chemical compatibility with aluminum and titanium alloys as well as the components of typical corrosion-inhibiting primers. The degree of organosilane hydrolysis and aqueous solubility was controlled by formulation pH and by blending various organosilanes. The addition of organosilanes to water does not significantly change the viscosity but can have a dramatic effect on the surface wetting characteristics of the resulting solutions.

2.3 Preparation of Aluminum Panels for Laboratory Cyclic Corrosion Testing

Corrosion test panels were prepared by the NA-PAST process for cyclic corrosion analysis. Water pressures of 40,000-45,000 psi was used to prepare Al 2024-T3, 6061-T6, and 5086-H321 panels. The experimental corrosion-inhibiting primer for this evaluation was ACP-6, which was found to yield the best and most consistent results in continuous salt spray testing (ASTM B117) for samples prepared by the abrasive PAST process. Some of the NA-PAST-treated panels were primed with a commercial corrosion-inhibiting primer conforming to MIL-P-53022. Some of the primed panels were coated with a chemical agent resistant coating (CARC) topcoat conforming to MIL-C-46168 and some were not topcoated. These specimens and suitable controls (solvent degrease, alkaline clean, acid etch, desmut, Alodine®, MIL-P-53022) were tested in accordance with GM Spec 9540P, Method B and evaluated to ASTM D-1654, Procedure A.

3.0 Results of Corrosion Testing of Specimens Treated by NA-PAST Method

Coated corrosion test specimens (ten specimens per condition) prepared from Al 2024-T3, 5086-H32, and Al 6061-T6 alloys by the optimized NA-PAST/MPD/ACP-6 process and control pretreatments were tested for corrosion resistance under cyclic exposure (per GM Spec 9540P, Method B) and found to exhibit excellent corrosion resistance as rated according to ASTM D1654. The corrosion test results after 2,000 hours of cyclic exposure are provided in Table 1 below. The NA-PAST pretreatment yielded excellent corrosion resistance for all of the aluminum alloys tested and was found to be most effective on the 5XXX series aluminum substrate. In general, the ACP-6 waterborne primer was more effective over NA-PAST-treated substrates than the control (MIL-P-53022).

Table 1
Coating Performance Ratings for NA-PAST Treated Aluminum Samples After 2,000 hr GM Spec 9540P Cyclic Corrosion Exposure

Sample

Primer

Topcoat
Unscribed Area Failure (%) Rating at
Unscribed
Area
(0-10) Average Scribe Creepage (mm) Rating at
Unscribed
Area
(0-10) NAP:P-6:TC:24 ACP-6 MIL-C-46168 0 10 0 10 NAP:P-6:24 ACP-6 0 10 0 10 NAP:MP:24 MIL-P-53022 0.401 9 0.021 9 CCC:MP:TC:24 MIL-P-53022 MIL-C-46168 0.049 9 0.015 9 NAP:P-6:TC:60 ACP-6 MIL-C-46168 0.15 9 0 10 NAP:P-6:60 ACP-6 0 10 0 10 NAP:MP:60 MIL-P-53022 0.26 9 0 10 CCC:MP:TC:60 MIL-P-53022 MIL-C-46168 0 10 0 10 NAP:P-6:TC:50 ACP-6 MIL-C-46168 0 10 0 10 NAP:P-6:50 ACP-6 0 10 0 10 NAP:MP:50 MIL-P-53022 0 10 0 10 CCC:MP:TC:50 MIL-P-53022 MIL-C-46168 0 10 0 10 Coated corrosion test specimens (ten specimens per condition) were prepared from cold rolled steel Q-Panels by the optimized NA-PAST/MPD/ACP-6 process and control pretreatments and tested for corrosion resistance under cyclic exposure. The control pretreatment was a Q-panel-supplied zinc phosphate coating (ZPC). The corrosion test results, as rated according to ASTM D1654 after 200 hours of cyclic exposure are provided in Table 2. In addition, three corrosion-resistant metal alloys (titanium 6/4, 301 stainless steel, and cartridge

brass) were prepared from by the optimized NA-PAST/MPD/ACP-6 process and tested for corrosion resistance under cyclic exposure. Those corrosion test results are provided in Table 3.

Table 2
Corrosion Performance Ratings for Low Carbon Steel 1010 Alloy
Pretreated by NA-PAST and Control Methods
200 hr GM Spec 9540P Cyclic Corrosion Exposure

Sample*

Primer Unscribed Area Failure
(%) Unscribed Area
Rating Avg. Scribe Creepage (mm) Scribed
Area
Rating NAP:P-6:LCS ACP-6 0 10 0.012 + 0.007 9 ZPC:P-6:LCS ACP-6 0 10 0.11 + 0.02 9 NAP:MP:LCS MIL-P-53022 0.05 + 0.09 9 0.06 + 0.02 9 ZPC:MP:LCS MIL-P-53022 0 10 0.4 + 0.0 9

Table 3
Corrosion Performance Ratings for Assorted Alloys
Pretreated by NA-PAST Method
500 hr GM Spec 9540P Cyclic Corrosion Exposure

Sample*

Alloy

Primer Unscribed Area Failure
(%)

Unscribed Area Rating
Avg. Scribe Creepage (mm)

Scribed
Area Rating NAP:P-6:SS Stainless steel ACP-6 0 10 0 10 NAP:MP:Ti Ti 6Al-4V MIL-P-53022 0 10 0 10 NAP:P-6:Ti Ti 6Al-4V ACP-6 0 10 0 10 NAP:P-6:CB Cartridge Brass ACP-6 0 10 0 10

The corrosion resistance measured for the bare CRS substrates prepared by the optimized NA-PAST/MPD/ACP-6 process compared quite favorably with the zinc phosphate control. The most sensitivity was found for panels primed with MIL-P-53022. Zinc phosphate-coated CRS panels primed with the control primer exhibited the highest degree of blistering around the scribed areas.

Excellent corrosion prevention and primer coating adhesion maintenance was observed for the three corrosion-resistant alloys prepared by NA-PAST with both waterborne ACP-6 primer and MIL-P-53022.

4.0 CONCLUSIONS

Specifically, the NA-PAST research program resulted in the following observations and accomplishments:

- Prototype NA-PAST apparatus built and successfully tested

- Rapid paint removal and metal surface abrasion demonstrated by NA-PAST

- NA-PAST-treated aluminum specimens exhibited comparable corrosion resistance and paint adhesion to specimens treated by control methods including chromate conversion coatings after 2,000 h of cyclic corrosion test exposure (GM Spec 9540P)

Further research (not shown above) also indicates:

- NA-PAST-treated 2024-T3 aluminum specimens readily accepted a commercial electrocoat primer and the resulting panels exhibited excellent corrosion resistance and primer adhesion durability after 2,000 h of salt spray test exposure (ASTM B117).

- NA-PAST-treated 5083-H321 aluminum specimens readily accepted both powder and electrocoat primers and the resulting panels exhibited excellent corrosion resistance and primer adhesion durability after 3,500 h of salt spray test exposure (ASTM B117).

- NA-PAST-treated aluminum specimens have exhibited comparable adhesive bond mechanical properties and bond durability under hot/wet conditions to specimens treated by control processes including phosphoric acid anodizing and chromated primers with a number of different aluminum alloys.

The most effective set of blasting conditions for bonding with aluminum alloys was found to be: 40,000 psi at a stand off distance of 0.5 in with a blasting rate of 1.25 in/s. These parameters yielded the most uniformly abraded surfaces without severe structural deformation. The effect of delay or out time between process steps was found to be critical for optimum bond durability. The time between waterjet abrasion and silane application was found to be the most important and should be kept as short as possible not exceeding one hour. The time between silane application and priming was found to be most important and should be kept below 24 hours at room temperature. The out time between silane cure and e-coat primer application for paint primers does not appear to be as critical. The degree of bond durability was found to be best for low copper aluminum alloys such as 5083.

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TRANSFERRING THE FLASHJET® COATING REMOVAL PROCESS TO DEPARTMENT OF DEFENSE FACILITIES

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ABSTRACT

For the past ten years there have been efforts by private industry and the Department of Defense (DOD) to find environmentally compliant methods for removing coatings off of substrates. This thrust has focused on finding depainting methods that minimize the use of hazardous substances. One environmentally compliant depainting method developed includes the combination of the xenon-flashlamp and carbon dioxide depainting technologies. This method is better known as the FLASHJET® coatings removal process.

The FLASHJET® coatings removal process has great potential for depainting activities within the DOD. The U.S. Navy has recently approved the use of the FLASHJET® coatings removal process on metallic fixed wing aircraft and there are many more applications within the three services where the FLASHJET® process can be utilized. For this reason the U.S. Army Environmental Center has partnered with experts on depainting processes from the U.S. Army, U.S. Navy, U.S. Air Force, the National Defense Center for Environmental Excellence (NDCEE), and The Boeing Company (formerly the McDonnell Douglas Corp.) to look at incorporating the FLASHJET® coatings removal process into DOD processes which currently use other harmful depainting methods. This project team has received funding support from the Environmental Security Technology Certification Program (ESTCP).

This 18-month ESTCP demonstration/validation will be conducted in two segments. The FLASHJET® coatings removal process will be evaluated on rotary wing aircraft during the first year of the demonstration. Ground vehicles including one Bradley Fighting Vehicle are scheduled to be evaluated in the second year of the demonstration.

BACKGROUND

In 1987 a study performed at the U.S. Air Force Sacramento Air Logistics Center evaluated xenon-flashlamps for removing aircraft coatings. The results of the evaluation concluded that although the xenon-flashlamp could remove aircraft coatings from metallic and composite

substrates to the primer, high temperatures were recorded on the substrate and the effluent ash was not being contained. The xenon-flashlamp technology proved to be effective; however there were still some issues that needed to be addressed. In 1990 the Warner-Robins Air Logistics Center looked into using carbon dioxide pellet blasting to remove paint from metallic structures. The process was proven effective, but there were concerns regarding the stripping of composite and thin metallic substrates. In 1990 a team of engineers from the McDonnell Douglas Corp., Cold Jet Inc., and Maxwell Laboratories Inc. combined the xenon-flashlamp and carbon dioxide pellet blasting technologies into one process, and this became what is called the FLASHJET® coatings removal process.

THE FLASHJET® PROCESS

The FLASHJET® process combines a xenon-flashlamp with low pressure carbon dioxide (dry ice) pellet blasting. The xenon-flashlamp is the primary coating removal mechanism. Pulsed-light energy generated from the xenon-flashlamp ablates the coating, reducing it to a fine ash. The xenon gas absorbs the electrical energy and releases photons that are emitted from the flashlamp head, which pulses 4 to 6 times per second. A continuous stream of dry ice pellets are also used in the process. Dry ice pellets cool and clean the flashlamp and the underlying substrate, which can reach temperatures as high as 230°F. The dry ice pellets also sweep away the effluent ash, which is vacuumed into an effluent capture system. This effluent capture system contains a series of High Efficiency Particulate Air (HEPA) filters that capture the effluent ash. These spent HEPA filters are the only waste created in the FLASHJET® process. All HEPA filters are tested for toxicity characteristics and then sent to designated landfills. The carbon dioxide used in the FLASHJET® process is captured from industrial sources and re-used to produce the dry ice pellets, thus no net addition of carbon dioxide is emitted into the atmosphere during the stripping process. Organic vapors generated during the ablation of the coating are vacuumed into the effluent capture system and processed through an activated charcoal tank.

The FLASHJET® process is a fully automated process with limited operator involvement. Once a new piece of equipment is rolled into the stripping area, operators program scan paths which the robotic FLASHJET® stripping head follows during the stripping process. Scan paths are saved on a central computer and used when the next similar application is ready to be stripped, thus no additional programming is required. As required by the Occupational Safety and Health Administration, 2 operators need to be present at all times during the operation of robotic controls; therefore this rule applies to the FLASHJET® process. These operators are shielded in a designated control room from the harmfully bright ultraviolet light, the loud noise generated during the ablation process, and carbon dioxide levels inside the stripping bay.

Figure 1 is a picture of the FLASHJET® process removing the topcoat from an AH-64A Apache fuselage at The Boeing Company's FLASHJET® Paint Stripping Facility in Mesa, AZ.

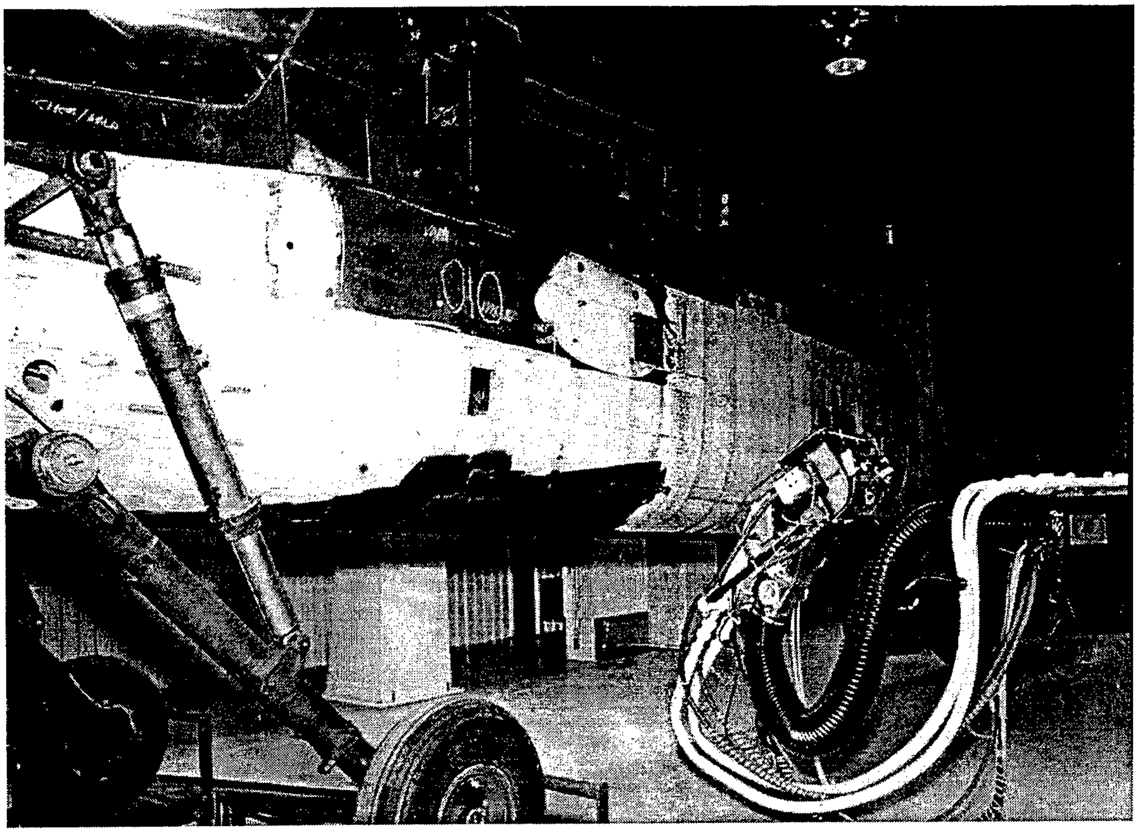

Figure 1: AH-64 Apache Helicopter being stripped using the FLASHJET® process

TECHNICAL MATURITY

In 1991 the Warner-Robins Air Logistics Center (WR-ALC) contracted with the McDonnell Douglas Corp. to produce a "proof-of-concept" 6-inch lamp prototype for stripping F-15 composite type parts. This 6-inch lamp was proven successful in stripping F-15 Boron/Epoxy vertical stabilizers. This was the first proof that the FLASHJET® coatings removal process would be able to strip composite type materials without damage to the substrate. With the success of the 6-inch prototype FLASHJET® system, the U.S. Navy began to take an interest in the FLASHJET® process. A follow-on study was initiated by the Naval Aviation Depot – Jacksonville (NADEP-JAX) to look at metallic and other composite materials testing.

The results of the initial testing proved that the FLASHJET® coatings removal process is a viable technology for stripping composite and thin metallic substrates without any damage to the substrate. In 1994 WR-ALC and NADEP-JAX teamed up and submitted a Strategic Environmental Research and Development Program (SERDP) project titled "Aircraft Depainting Technologies." This SERDP project looked to further validate the FLASHJET® coatings removal technology by performing further testing on aircraft substrates. Results from this testing led to Naval Air Systems Command approval for use of the FLASHJET® process on metallic fixed wing aircraft. Another objective of this SERDP project was to develop a mobile manipulator where the FLASHJET® stripping head could be attached to a robotic arm for

stripping equipment, including fully assembled aircraft, without total disassembly. The operator of the mobile manipulator could simply drive up to the piece of equipment and strip the equipment through the use of robotic controls. This mobile manipulator will be tested at NADEP-JAX on P-3 cargo aircraft in 1998.

The FLASHJET® coatings removal process has been extensively tested on other types of substrates and composites during its short history at The Boeing Company FLASHJET® Demonstration Paint Stripping Cell in St. Louis, MO and at the NDCEE in Johnstown, PA. Since 1996 The Boeing Company has been using the FLASHJET® process to strip AH-64A Apache fuselages at their AH-64A Apache FLASHJET® Paint Stripping Facility in Mesa, AZ. To date over 40 AH-64A fuselages have been stripped using the FLASHJET® process at the Mesa, AZ plant, at an approximate life cycle cost of $3.75/ft^2$.

DEMONSTRATION PLAN

This demonstration will look to validate the FLASHJET® coatings removal process on certain rotary wing and ground vehicle applications. Rotary wing applications to be demonstrated include the SH-60 and CH-53 off-aircraft components. Along with testing the equipment listed above, the U.S. Navy and U.S. Air Force project representatives will be conducing a High Cycle Fatigue Testing program to qualify the use of the FLASHJET® coatings removal process on 2024 T3 and 7075 T6 Aluminum rotary wing aircraft substrates. Results of this testing program will determine if the FLASHJET® process causes damage to these rotary wing aircraft substrates. Rotary wing application testing will be conducted in FY98. Ground vehicle application testing is planned for FY99. Ground vehicles to be evaluated include the Bradley Fighting Vehicle, the High Mobility Multipurpose Wheeled Vehicle, and a Command and Communications Shelter. All equipment evaluated in this demonstration will come under review of the Program Managers (PMs) of the tested equipment via a Joint Test Protocol (JTP), similar to the JTP format developed by the Joint Group for Acquisition Pollution Prevention. The JTP documents the testing that will be conducted on the PM's equipment and the criteria that will be used for determine the viability of the FLASHJET® process on their equipment. If all requirements are found within the JTP that are needed to qualify the FLASHJET® process on the weapon system, then the Program Manager gives an endorsement for the demonstration and will consider the technology if the results of the evaluation are acceptable.

The FLASHJET® demonstration will be conducted at The Boeing Company's AH-64A Apache FLASHJET® Paint Stripping Facility in Mesa, AZ. Once Program Managers of tested equipment endorse the JTP, the evaluation will begin in the summer of 1998.

COST SAVINGS

During the equipment evaluation, certain cost variables will be recorded, and an estimated life cycle cost per square foot will be calculated. The Environmental Cost Analysis Methodology (ECAM) model prepared by the NDCEE will be used as the primary life cycle cost estimating model for this demonstration. Along with the ECAM model, the U.S. Air Force Depaint Cost

Comparison Model developed by Randy Ivey from WR-ALC will be used as another model for estimating life cycle costs. This WR-ALC cost model has been extensively evaluated on aircraft at several Air Force and Navy installations. The model is also being used to estimate life cycle costs for ground vehicle applications at Army and Marine Corps installations.

Recently the WR-ALC model was used to determine an estimated life cycle cost per square foot for the U.S. Army National Guard's 1108th AVCRAD at Gulfport, MS. Currently the 1108th AVCRAD uses plastic media blasting to depaint rotary wing aircraft, including the UH-60, AH-64, UH-1, AH-1, and OH-53, and the 1108th AVCRAD personnel wanted an estimated life cycle cost per square foot for using the FLASHJET® process versus plastic media blasting. Table 1 gives an estimated life cycle cost per square foot for FLASHJET® versus plastic media blasting. The life cycle cost figures for the FLASHJET® process are significantly lower due to the limited worker involvement and minimal waste disposal.

Table 1: Estimated Life Cycle Costs Per Square Foot for the 1108th AVCRAD, MS

Aircraft	Plastic Media Blasting	FLASHJET®
UH-60	$21.94	$3.62
AH-64	$22.45	$3.83
UH-1	$20.04	$4.03
AH-1	$25.47	$4.17
OH-58	$34.04	$3.62

CONCLUSIONS

At the conclusion of this 18-month demonstration, the FLASHJET® coatings removal process will be proven as a viable technology for most rotary wing and ground vehicle applications. Results of the High Cycle Fatigue Test will show that the FLASHJET® process is a safe alternative for coatings removal for certain rotary wing aircraft substrates. Estimated life cycle costs calculated in the demonstration will show that the FLASHJET® process will save DOD depainting installations money over other commonly used depainting methods that have higher life cycle costs.

ACKNOWLEDGEMENTS

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Session XIX
P^2 Success Stories

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P2 Success Story: Fort Lewis Fuel & Water Recovery Program (#128)

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Introduction: This paper will celebrate a pollution prevention success story. The paper will be viewed from the past present and future. The past perspective will show good hazardous waste management with tons of value being manifested off-site. The present perspective will show the end of a waste stream and the beginning of a new on-site recycling industry. The future will show maintenance revolutionized and practically all off-site vehicle process waste eliminated and recycled.

The Past: For many years, tens of thousands of gallons of contaminated diesel and JP-8 were sent off-site in drums as hazardous waste. And for many years we have had a significant commitment of manpower and money dedicated to the management of contaminated fuel. The most common problem with all the wasted fuel was water and dirt contamination. Fuel tanks on vehicles or in underground tanks suffer from the same problem. Moisture from the air condenses and collects on the bottom of the tanks. Microscopic organisms live in the water and eat the fuel. As the organisms eat and die, the water becomes saturated with slime and sludge that builds up on the tank bottom and eventually clogs filters. The only effective method of dealing with this problem in the past was to pump the tanks empty and dispose of the contaminated fuel off-site through D.R.M.O. Even if waste disposal were free, the re-purchase of fuel alone makes this practice a loss of value.

Any waste we generate is a potential liability due to it's associated environmental risk. When we pay private companies to manage the disposal of our waste we are still not free of the liability for environmental damage if something goes wrong. The law makes us liable for our waste from cradle to grave. For this reason we are always looking for ways to decrease the amount of waste sent off-site, thus decreasing our potential liability. When we manage things on-site we retain complete control. If we can turn contaminated fuel into useable fuel on-site we save money and sleep better at night.

The Present: We are now managing the collection and storage of the contaminated fuel on-site and in bulk tanks rather than in drums. We pay industrial contractors for the technology service that recycles the fuel at our central bulk facility rather than sending drums of waste fuel off-site. The recovered fuel is then analyzed by the US Army Petroleum Laboratory, and donated back to the soldiers for use in tracked armored vehicles. The water that was removed from the fuel is cleaned to meet local pretreatment standards for discharge to the sanitary sewer. We now spend far less money on recycling services than off-site waste management and disposal. We also have the added benefit of the recovered fuel for donation back to the Army units. By managing the fuel as a recyclable commodity we have lightened the annual dangerous waste-reporting burden. By handling the fuel in bulk we spend less money on the purchase of disposal drums.

Economic Benefit: For each gallon of contaminated fuel handled by this program, Fort Lewis, the US Army and the taxpayers save **$1.44** compared to the previous practice. In 1997, we processed over sixty-five thousand gallons of contaminated fuel. From that contaminated fuel we harvested 50,000 gallons of good fuel for an estimated cost saving of **$93,600**. The recycled fuel was issued to and consumed by US Army main battle tanks. Nearly 500,000 pounds of waste reduction has been achieved during the past eighteen months of the program. Local leaders that were at first skeptical have now "bought in" to the idea that recycled fuel is OK. We have constructed a new production facility that is especially designed for the on-site recycling of fuel, water and other liquids. The total capital investment for this project was $152,000. Operations and maintenance costs for the previous practice cost over $190,000 per year. The new program costs $61,000 per year. Payback for this project is 1.17 years and has an estimated net present worth of $926,264. In this age of ever shrinking budgets and ever increasing responsibilities we are very proud of this achievement and the on-going opportunity to add value to the Army mission. Consider the table below for a comparison of the old way with the new way.

P2 Success Story: Fort Lewis Fuel & Water Recovery Program (#128)

Direct Savings per Gallon.

ITEM	OLD	NEW
Labor	**NA**	**NA**
Original Purchase Cost	**NA**	**NA**
Re-Purchase Cost	**$.80**	**NA**
Average Disposal Cost Per Gallon	**$1.54**	**$0.00**
Average Recycling Charge Per Gallon	**NA**	**$0.90**
Total Direct Cost Per Gallon	**$2.34**	**$0.90**
Direct savings Per Gallon	**NA**	**$1.44**

Continuing Developments: We have conducted successful trial runs with solvent; petroleum based hydraulic fluid and fire resistant hydraulic fluid. We now intend to apply the same techniques to these commodities that we have with the fuel. Perhaps we can eliminate several more waste streams by recovering and reusing the same coolants and lubricants over and over. Now that we have found real value in what was previously considered waste, we are anxious to try it again.

On-Site Recycling Helps Us Meet Our Goals: Turning waste into reusable fuel on-site is by far the most important achievement of this program. Our higher headquarters mandates us to achieve four goals. Our first goal is to maintain 100% environmental compliance. Our second goal is to minimize negative impacts to Army training. Our third goal is to simplify environmental requirements for the soldiers. Our fourth and final goal, environmental stewardship is what we must strive toward. We are delighted by the fact that in this program we can claim true progress toward all of our goals.

The **goal of 100% compliance** is more easily achievable as we remove waste streams that must be managed under the hazardous waste regulations. Managing contaminated fuel as a recyclable commodity is cheaper than managing it as a hazardous waste. Environmental compliance under the Resource Conservation and Recovery Act or RCRA (hazardous waste regulations) is tough and expensive. The State version of this federal law is no less forgiving. There are special requirements for accumulation, storage, handling, transportation, and disposal. There are special training requirements for personnel that handle any waste regulated under RCRA. Special inspections and reports are required under the hazardous waste regulations. This on-site fuel-recycling program allows us to manage the contaminated fuel as if it were never a waste. And indeed it is no longer a waste. This on-site fuel recycling program helps us maintain 100% environmental compliance.

Minimize negative impacts and simplify environmental requirements: In the case of this program the second and third goals are achieved together. Our mission at Fort Lewis is to maintain and train troops for combat. Anything that distracts or takes away from that mission is considered a negative impact on Army training. Environmental requirements placed upon the troops that are confusing and complicated are consequently an impediment to that training mission. The on-site fuel recycling procedures are less complex for the soldiers and thus directly benefit the training mission by making contaminated fuel management easier.

Environmental stewardship is achieved as a result of this program in several ways. Waste reduction is beneficial to the environment and the economy. Less total demand for petroleum production is required from the global reserves when we reduce the amount of waste fuel we generate. By wasting less, we handle and haul less and therefore decrease the risk of fuel spills to the environment. By spending less money on waste management, we require less money to operate. By assigning a positive value to the contaminated fuel, we help decrease the likelihood of the contaminated fuel becoming abandoned hazardous waste and threatening the environment. By using the fuel for its intended purpose we restore the highest value back to the commodity.

The soldiers at Fort Lewis have an important real world mission. As environmental professionals we have the mission of **lifting the environmental burden** from the soldiers. This allows them to avoid distractions from their training mission. Our on-site recycling program empowers us to provide more comprehensive

and responsive customer service to the soldiers. Recycling fluids on-site is simpler and cheaper to manage than sending hazardous waste off-site.

Results Are Replicable: This on-site fuel-recycling program is 100% replicable and exportable to any place that generates contaminated fuel. The highly technical aspects of this program were all out-sourced by outside technology providers that are portable to any place at any time. No new technology has been invented as a result of this program. This program has merely utilized a different application of existing technologies. Government facilities are perhaps the most likely candidates for getting the best advantage from this type of program. Facilities with the largest fuel waste streams will receive the most dramatic results and fastest payback on capital investment. A new on-site recycling industry has started.

The Last Remaining Problem: Cross contamination of fluids during collection is the most prevalent reason that causes failure for any kind of liquid recycling program. Straight JP-8 contaminated with water and dirt is very easy and cheep to process. However, when used motor oil is added into the mixture, the recycling task becomes more difficult and expensive. JP-8 and small amounts of gasoline create a mixture that is not safe for our program to deal with effectively. We provide separate collection containers for all waste generated on post. We also spend a large amount of time and effort on our education program and public out reach to address the cross contamination issue. But the problem of cross contamination still exists. People in a hurry to get the fluids drained do not care enough to take a few extra seconds to use separate containers for different fluids.

The solution to the cross contamination problem can be found in an **improved collection system**. As long as the spent fluids remain as segregated as they are inside the vehicle they can be recycled. We have noticed that draining fluids into pans and cans is where the cross contamination begins. The antifreeze is drained into the same pan that was previously used to collect the engine oil. The oil residue from the pan is mixed into the antifreeze and goes into the antifreeze collection container. Fortunately the oil floats to the top and does not present much of a problem. The big problem comes when miscible products get mixed together. The fluid collection system must have the ability to evacuate fluids through dedicated pathways that are hard piped to dedicated bulk collection tanks to await the recycling process.

The Future: Construct a facility that would operate similar to Jiffy Lube, Q Lube and other commercial establishments for tactical military vehicles. The purpose of the facility would be to provide rapid fluid evacuation and filter change for all coolants and lubricants. Additionally, the majority of the coolants and lubricants taken from the vehicles could be recycled and reused on-site. The estimated economic benefits from this proposed facility are numerous. However, the most significant and immediate payoff would be an enormous reduction in maintenance and waste management requirements on the military personnel.

Strategy: By using the same fluids over and over again in the tactical Army vehicles, a large amount of money can be saved. Tests have shown that it is possible to recycle on-site many fluids such as fire resistant hydraulic fluid, antifreeze and petroleum based hydraulic fluid and motor oil. In the case of waste streams that can not be recycled on-site, the off-site bulk recycling option could be easily exercised. The largest challenge faced by fluid recyclers is cross-contamination of fluids. Bulk collection through dedicated vacuum lines into dedicated bulk tanks will completely eliminate the possibility of cross contamination and enable recyclers to provide competitive recycling rates.

The prototype for the fluid recycling portion of the facility already exists on Fort Lewis where contaminated fuel is segregated prior to being processed and recycled. The vacuum fluid handling equipment necessary to pipe the used fluids into bulk collection tanks and dispense the recycled fluids back into the vehicles is easy to obtain. Only minor modifications would be required for refitting a modern civilian fluid evacuation and replacement facility into one suitable for Army use. An in-house design study would reveal how many service bays and technicians would be required to serve the Army efficiently.

Additional Benefits: By centralizing the fluid evacuation process, the environmental reporting burden could be substantially reduced. Currently the environmental staff relies upon units conducting quarterly hazardous materials inventories. The existence of the centralized facility could greatly reduce and

simplify this unit requirement. By handling all fluids in bulk, the proposed facility would eliminate the disposal of many tons of empty containers each year. Any additional purchase of coolants or lubricants for use at the facility could be made in reusable bulk containers. Any off-site recycling or off-site waste management could also be managed in bulk, which would greatly reduce the amount of waste containers purchased each year.

Strength of Focus: Currently, the soldiers that manage evacuated fluids as hazardous or non-hazardous waste do so well outside their given career fields. Soldiers need to spend more time on activities that help their careers by performing their military mission and becoming technically proficient in their jobs. Any military mechanic that regularly performs or supervises vehicle fluid and filter changing services will admit that it is a task they would gladly give up in order to perform tasks of greater complexity. A facility operated by contract personnel that are well motivated could provide this service at a profit and still provide a gigantic value to the government. In addition to fluid and filter evacuation and changing activities, a 50 point PMCS inspection could be performed as part of the service. This information could be reported back to the command electronically and provide valuable and impartial readiness information to unit commanders.

Summary: The cost of virgin products coupled with handling and disposal of coolants and lubricants could perhaps offset the cost for the evacuation and replacement service at no extra cost to the government. In other words the coolants and lubricants needed to maintain military vehicles ten years from now are running around inside the equipment right now. Standard software that is already available could be used to maintain records and schedule services. The reduced cost of fluid and filter change could encourage the increased frequency of fluid change and extend the life of the vehicles. This P2 Success Story is about one P2 project preparing the way for the next one. This on-site recycling experience has prepared us for greater challenges and inspired us to reach for higher goals.

RECYCLING OF HAZARDOUS MATERIALS AT MCCLELLAN AFB UNDER A RCRA EXCLUSION

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Abstract

McClellan Air Force Base (AFB) has obtained written approval from the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) to recycle certain hazardous materials under exclusions from federal and state hazardous waste regulations. Specifically, DTSC has concurred that the Seiler High Temperature Vitrification process can be used to recycle three types of waste: steel mill dust, garnet blast media residuals, and industrial wastewater treatment sludge generated at McClellan AFB. The proposed recycling qualifies for exclusion under 40 Code of Federal Regulations (CFR) 261.2(e) and (f), as well as California Health and Safety Code 25143.2(b). The approval clears the way for McClellan and other DoD installations to recycle hazardous materials (without hazardous waste permits) that are currently being disposed of as hazardous waste, thereby reducing costs and long-term liability.

Several points were key in obtaining approval. Bench-scale and pilot-scale studies demonstrated that the wastes can be successfully recycled into non-toxic, commercial glass/ceramic products, such as abrasives, roofing tile granules, and architectural materials. Detailed chemical and physical characterizations showed that the wastes contained components essential to producing acceptable products, and that materials were not being burned for destruction or for energy recovery. Additional technical information was provided to DTSC to show that wastes were not being "reclaimed," and that recycled products would not be used "in a manner constituting disposal."

In granting approval of the recycling exclusion, DTSC has also established the mechanism through which detailed information on other wastes can be reviewed and approved, if appropriate, for the recycling exclusion. Wastes containing silica and/or transition metals, with low organic content, are suitable for vitrification. The work done by McClellan AFB has laid the groundwork for recycling a multitude of suitable materials from DoD installations as well as private industry.

Background

McClellan Air Force Base, together with Radian International LLC, has explored the potential for vitrification technology to recycle several materials currently being disposed of as hazardous

waste. Such an approach has three main benefits:

- Recycling hazardous wastes into marketable products diverts hazardous wastes from landfills and incinerators.

- Long-term liability associated with conventional disposal methods is eliminated.

- Recycling can be accomplished at a lower cost than for treatment/disposal.

Federal and California state hazardous waste regulations offer exclusions for materials that are recycled, meaning that such materials are not regulated as hazardous waste, and that the recycling facilities are not regulated as treatment facilities. An exclusion makes the technology easier to apply, because hazardous waste permits are not required. However, there are several criteria that must be satisfied before a recycling operation can be considered excluded.

Regulatory Requirements

The requirements to be satisfied for a recycling exclusion are stated in nearly identical language in both the federal[1] and state of California[2] regulations. The key regulatory requirements are:

- The recyclable material must be "used or reused as an ingredient in an industrial process to make a product."

- The materials must not be "reclaimed," that is, the process must not separate desirable constituents from undesirable constituents.

- The materials must not be "used in a manner constituting disposal or used to produce products that are applied to the land."

- The materials must not be "burned for energy recovery, used to produce a fuel, or contained in fuels."

- The materials must not be "accumulated speculatively."

Seiler High Temperature Vitrification Process

The High Temperature Vitrification Process, developed by Seiler Pollution Control Systems, Inc., has been evaluated for application at McClellan AFB. High-temperature vitrification is the process of converting materials into glass by heat, fusion, and cooling. The Seiler system uses a high-temperature (>1500°C) molten bath to convert suitable hazardous materials into a glass/ceramic product. In the process, the inorganic constituents are incorporated into a silicate matrix, making heavy metal contaminants virtually unleachable. The vitrified product has chemical and physical properties suitable for commercial use as medium-grade abrasives, roofing granules, architectural materials, or insulating materials.

Feed materials are blended together into formulations that, when vitrified, make products with the desired properties. Hazardous wastes containing silica and/or transition (heavy) metals are suitable for recycling by the Seiler process.

Gaining Agency Approval

In January 1997, a formal request was submitted to the California Department of Toxic Substances Control (DTSC) by McClellan AFB for approval to recycle waste materials using the Seiler process. (DTSC has the authority for administering hazardous waste regulations in California.) The request included a detailed analysis of the regulations, together with specific evidence showing how the proposed recycling operation would meet those requirements. Follow-up discussions were held with DTSC during their review, and technical issues were discussed in detail over the next several months. Finally, in September 1997, DTSC issued a letter of concurrence, stating that three waste streams – steel mill dust, garnet blast media residual, and McClellan's industrial wastewater treatment sludge – can be recycled using the Seiler process under exclusion from hazardous waste regulations.

Several points were key in obtaining approval. First and foremost was to demonstrate that the requirement for the material to be "used or reused as an ingredient in an industrial process to make a product" is satisfied. Physical and chemical characterizations performed during bench- and pilot-scale testing were used to prove that waste materials could be successfully transformed into products with commercial value, such as abrasives, roofing granules, and architectural materials. Product specifications were shown to be satisfied, and letters from potential buyers of the product demonstrated its commercial value.

The issue of materials being "reclaimed" was important in the determination. Although the Seiler process does separate constituents into distinct products, it is virtually impossible to vitrify commonly encountered waste materials without reducing mass through the evaporation of water, release of carbon dioxide from the decomposition of carbonates, or the oxidation of organic compounds. DTSC did not set specific criteria to be met on this issue, instead preferring to approve waste streams on a case-by-case basis. Acceptable materials should be composed primarily of inorganic compounds which have been shown to be essential to the formation of acceptable products, with low levels of organic compounds (especially regulated organic compounds). The general guideline is that the process should be used primarily to recycle the material, not to destroy significant quantities of undesirable organic compounds. In addition, DTSC has established a limit on the thermal value of recyclable materials of 5,000 Btu/lb to ensure that materials are not burned for energy recovery.

Under the recycling exclusion, materials cannot be recycled into products that are applied to the land (such as road base). Because Seiler has developed specific applications for the vitrified product, this requirement is easily met. Products such as abrasive materials, roofing granules, and architectural materials do not involve land application.

Recyclable materials cannot be "accumulated speculatively," that is, they must not be stockpiled to wait for a market to develop or to wait for more favorable market conditions. Seiler has been

able to demonstrate, using letters from abrasive manufacturers and other interested companies, that there is a market for the vitrified product. In addition, operational restraints can be put into place such that materials are not stockpiled for speculative purposes.

Framework for Future Recycling

In obtaining DTSC's concurrence for the recycling exclusion, McClellan AFB has established the framework for recycling wastes through vitrification. A multitude of materials from other DoD installations as well as private industry are suitable for vitrification. Detailed data on additional waste streams will be submitted to DTSC so that the list of acceptable materials can be expanded. Other state agencies may be able to follow DTSC's precedent in approving recycling exclusions for the Seiler process. In the future, Seiler intends to install full-scale vitrification systems in the United States so that the benefits of this recycling technology can be realized.

References

1. *Code of Federal Regulations*, Title 40, Part 261.2.

2. *California Health and Safety Code*, Section 25143.2.

ABERDEEN PROVING GROUND POLLUTION PREVENTION HANDBOOK

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INTRODUCTION

The development of the Aberdeen Proving Ground (APG) Pollution Prevention (P2) Handbook was based on the installation's location, mission, and personnel. APG supports an effective work force of 14,000 military and civilian personnel, as well as 4,800 military family members who reside on post. The APG P2 Handbook was written and developed with these personnel, their families, and the unique environment of the Chesapeake Bay in mind, stressing that P2 efforts by all at APG are a main priority. As a result, the Handbook is an easy-to-use document to aid all APG personnel in understanding the principles of P2 and in identifying and using environmentally responsible products and processes.

APG's Location: APG is located in Harford County, Maryland, near the head of the Chesapeake Bay. Environmental protection of the water, air, and land is a long-term, ongoing practice. APG, consisting of the Aberdeen and the Edgewood areas, comprises approximately 72,500 acres, nearly half of which is under water or marshy, wooded terrain. The remainder is low-lying, flat to gently rolling country.

The APG Mission: APG is an active U.S. Army Test and Evaluation Command (TECOM) installation within the U.S. Army Materiel Command (AMC). It includes 13 offices, 10 directorates, and approximately 58 tenant activities or liaison offices. Major tenants include the U.S. Army Test and Evaluation Command (TECOM), U.S. Army Aberdeen Test Center (ATC), U.S. Army Chemical and Biological Defense Command (CBDCOM), U.S. Army Research Laboratory (ARL), U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), U.S. Army Medical Research Institute for Chemical Defense (MRICD), U.S. Army Environmental Center (AEC), U.S. Army Ordnance Center and School (OC&S), Foreign Military Intelligence Battalion (FMIB), U.S. Army Materiel Systems Analysis Activity (AMSAA), and Kirk U.S. Army Health Clinic (KUSAHC).

APG's mission is as diverse as the tenant agencies that reside on the installation. APG tenants test and evaluate a large cross-section of soldier equipment, including vehicles, weapons, training devices, and clothing. Tenants plan and conduct development and production tests of weapons and weapons systems, armor plate, combat vehicles and general- and special-purpose vehicles. These tests span the materiel life-cycle from conceptual phase through production and actual deployments, including live fire vulnerability.

APG is also home to biological and chemical defense research, development, and engineering programs. Research is also conducted in soldier performance optimization, soldier-machine interactions, smart weapons systems, and computer technology.

In addition to its research an development mission, APG is the largest training center for military and civilian personnel in the field of maintenance and integrated management of combat fire power and ground mobility materiel. This training ranges from military occupational skill-producing courses for the new soldier, to mid-level leadership and supervisory instruction for junior noncommissioned officers, to technical enhancement courses for warrant officers, to leadership, resource management, and other advanced courses for senior officers (noncommissioned and commissioned).

The diversity in missions and potential environmental impacts associated with the Chesapeake Bay region were important considerations in the development of the P2 Handbook.

STRUCTURE AND CONTENT OF THE APG P2 HANDBOOK

The APG P2 Handbook provides up-to-date information on environmental issues and regulations related to pollution prevention. It provides Army-specific and APG-specific information to show readers how to implement P2 initiatives in their own lives. The Handbook also attempts to help readers understand why P2 is relevant to them and to their jobs. For example, it explains why the State of Maryland is non-compliant in that its air exceeds the regulated level for ground-level ozone, and describes the products and practices that contribute to ground-level ozone, such as those products that emit volatile organic compounds (VOCs). The Handbook offers substitutes for these VOC-emitting products and suggests process changes to decrease and eliminate this contributing factor to ground-level ozone.

The Handbook also provides a readily available resource to APG personnel, including shop personnel, technicians, and staff at the Command-level. Each module contains an *Additional Information Sources* section and references.

Structure: Each module of the APG P2 Handbook was designed to be short (5 to 10 pages), with narrowly focused information on a specific topic, and able to stand alone without extensive reference to other parts of the Handbook. The generic outline for each of the modules is as follows:

Section A: An introductory section, which clearly defines the purpose of the module, and shows how the information in the module is applicable to the end-user at APG.

Section B: The technical or regulatory information, which discusses the module topic as it relates to pollution prevention. This information was written for the non-technical reader, is presented in plain, understandable language and uses graphics to illustrate key points.

Section C: A summary section, which tells the reader where to go for more information on the topic. This section directs the reader to additional information sources.

The Handbook is presented in a three-ring binder to allow for easy revision and addition of modules. The modules are separated by tabs that are labeled with the corresponding module's topic. A separate index is provided so that the reader can easily find information of interest.

The original outline included an initial list of topics, but expansion on these ideas was anticipated. For example, the proposed topic of the environmental science of ozone and acid rain would be discussed as separate modules for each of the different types of products used by the operations at APG, and also for environmental issues of interest in addition to ozone and acid rain. By placing these in separate modules, the reader is able to look at the one module that focuses on their activity, and would not need to work through text on unrelated issues. Similarly, the suggested topic of environmental laws and Executive Orders could be expanded into two separate modules, one focusing on laws and orders that mandate pollution prevention and reporting, and the other focusing on laws that regulate the handling and disposal of hazardous materials.

It was expected that there would be some overlap in material between the modules. For example, the module on the environmental science of petroleum fuels will necessarily present some of the same information found in the module that discusses ozone and the greenhouse effect. However, this duplication was necessary to ensure that each module could stand alone.

Content: The APG P2 Handbook is an on-hand resource for shop and office personnel, and is the basis for subsequent APG pollution prevention training programs. The Handbook consists of 12 independent modules that describe APG pollution prevention practices and policies. Overviews of each module are presented below.

Air Pollution provides information on the sources and processes that produce air quality problems, such as acid rain, greenhouse effect, stratospheric ozone depletion, and ground-level ozone. The module describes the effects of each and identifies regulatory and technological control measures.

Chesapeake Bay is an overview of the sources of pollution that affect the quality of the Chesapeake Bay with a focus on APG activities and the Chesapeake Bay watershed.

Storm Water Pollution provides a detailed discussion of storm water pollution and its potential impact on water quality.

Solid Waste Management and Recycling is an overview of solid waste disposal and management issues, including construction and demolition debris. It discusses the types of wastes that APG generates and describes methods of managing solid waste and how each affects the environment and human health.

Hazardous Materials Management defines hazardous materials and provides guidance on how to properly handle them at APG. It also provides information on the purpose and operation of APG's hazardous inventory tracking system (HITS).

P2 Requirements summarizes regulations and executive orders applicable to APG's P2 program.

Material Safety Data Sheets explains how to obtain and review material safety data sheets in order to effectively identify chemical composition, health and safety information, spill cleanup requirements, and disposal requirements.

Environmentally Preferable Products provides guidance on how to identify and purchase environmentally safe products and services.

Life-Cycle Assessment describes how life-cycle cost analysis provides a complete picture of the costs and environmental effects of hazardous material procurement and disposal.

Green Building provides a detailed discussion of the green building concept, including issues related to acoustics, air quality, energy efficiency, historical and cultural resource preservation, resource conservation, waste management, and water conservation. It describes the environmental benefits of green building techniques and discusses the adverse impacts of traditional techniques.

P2 Success Stories presents examples of pollution prevention initiatives at APG and their results.

P2 Information Sources shows the reader how to obtain information on federal guidance documents, and provides APG P2 contacts, sources of technical information, and Internet guidance.

The handbook has three appendices:

Appendix A: Relevant Federal Environmental Laws
Appendix B: Pollution Prevention Executive Orders
Appendix C: Army Regulations

The following attachments are also included in the P2 Handbook:

1.1 Air Pollution Treatment Technologies
3.1 How Does Wastewater Differ from Storm Water?
4.1 CD Debris Recycling and Reuse Opportunities
5.1 APG Hazardous Materials Management Policy Memorandum and Hazardous Materials Management Procedures Handbook
5.2 Summary of Federal Acquisition Regulation (FAR) Changes to Implement Executive Order 12856
6.1 Army Sources
6.2 State Sources
6.3 National Sources
6.4 Regional Sources
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7.1 Federal Supply Class (FSC) Hazardous Items Requiring MSDSs
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TRANSPORTATION MODEL SHOP REPORT

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INTRODUCTION

The Air Force Center for Environmental Excellence (AFCEE) developed the Air Force Pollution Prevention (P2) Model Shop program to assist Air Force Bases (AFBs) with identification of pollution prevention opportunities (PPOs) and to consolidate efforts of performing pollution prevention opportunity assessments (P2OAs). AFCEE recognized that similar operations were being performed at AFBs, and similar opportunities were being identified. To eliminate this duplication of effort, AFCEE created the Model Shop program by focusing on operations performed in Transportation, Flightline Maintenance, Civil Engineering Operations, Entomology (Pesticides), Retail Sales Facilities, and Food Service Facilities.

The Transportation Model Shop Report was the first P2 Model Shop Report created by AFCEE to present PPOs relating to vehicle maintenance processes. Originally created as desktop summaries of several Air Force P2OAs, no field surveys or base site visits were conducted to validate the information presented in the original report. AFCEE contracted with Parsons Engineering Science, Inc. (Parsons ES) to update the Transportation Model Shop Report to include new PPOs, Management Initiatives, Good Ideas, and Product Substitutions; as well as to validate inclusion of processes performed at vehicle maintenance shops.

The first task included a review of the existing Transportation Model Shop Report and several existing P2OAs to compile a rudimentary list of processes performed and PPOs available to vehicle maintenance facilities. Two Air Force bases (F.E. Warren AFB and Davis-Monthan AFB) were then visited to collect information on the types of vehicle maintenance facilities, typical transportation related operations and processes, typical waste streams generated during vehicle maintenance operations, and waste reduction opportunities already employed. Additional bases (USAF Academy, Fort Carson, and Buckley Air National Guard) were surveyed to refine process descriptions and gather different PPOs and good ideas applicable to vehicle maintenance shops. Although the processes were similar at each shop, the materials used and methods for waste disposal varied considerably from base to base.

PROCESS DESCRIPTIONS

Twenty-two distinct processes are identified in the Transportation Model Shop Report. These processes were developed from the analysis of daily operations at the bases visited. Each process presented was selected because of its unique contribution to vehicle maintenance operations, its use of hazardous materials in the process, or its production of a hazardous waste stream. Some smaller operations were combined because of the minimal opportunities relating to the materials or wastes.

Each process is presented in a parallel manner including a detailed description of the operation; a process flow diagram depicting the materials used in the process and the waste streams produced by the process; and a table of the material inputs and waste streams. Also included with each process is a table summarizing the PPOs, Management Initiatives, and Good Ideas applicable to the process with references to the section with the detailed presentation.

The following is a list of processes presented in the Transportation Model Shop Report:

- Engine Oil and Filter Changes
- Hydraulic, Transmission, and Other POL Fluid Changes
- Antifreeze Changes
- Parts Washing
- Carburetor Cleaning
- Circuit Board Cleaning
- Brake Maintenance
- Battery Maintenance
- Tire Maintenance
- Air Conditioning Service
- Tune-ups, Lubing and Greasing
- Engine and Transmission Rebuilds
- Fuel Tank Maintenance and Fuel Filter Changes
- Radiator Repair, Body Work, Upholstery, and Glass Work
- Paint Removal and Sanding
- Painting
- Refueler Vehicle Tank and Pump System Maintenance
- Fire Truck Aqueous Film Forming Foam (AFFF) System Maintenance
- Vehicle Washing
- Alternative Fuel Vehicle Maintenance
- Rag and Absorbent Use / Spill Cleanup
- General Facility Maintenance

POLLUTION PREVENTION OPPORTUNITIES

Twenty-two PPOs are identified in the Transportation Model Shop Report. These opportunities are recommended to reduce the amount of waste generated and to improve vehicle maintenance processes to become more environmentally friendly. Each PPO has one or more recommendations (alternatives) to the status quo. The PPOs and alternatives were compiled from the existing Transportation Model Shop Report, existing P2OAs, opportunities observed during the base visits, and opportunities researched on the World Wide Web or other P2 resource publications.

Each PPO is presented with a detailed description of the opportunity, a discussion of alternatives, a table of advantages and disadvantages, a technical analysis, an economic analysis, and vendor and reference information. The detailed description presents the assumption of a status quo. The discussion of alternatives presents the separate recommendations identified for the PPO, including the status quo. A list of processes to which the opportunity is applicable is also provided. Two tables are then presented: one outlining the advantages and disadvantages for each alternative compared with the status quo, and the other summarizing the technical analysis, including space, utility, labor, and equipment requirements compared with the status quo.

Following the description and discussion of alternatives is the economic analysis, consisting of a Microsoft Excel spreadsheet with costs for the alternatives and status quo, and tables with the capital and annual operating cost assumptions. The spreadsheet is interactive in the electronic version so that the users can input individual costs to customize the economic analysis. A payback period is calculated for each alternative to help justify capital and annual operating costs compared to the status quo. The user is urged to enter specific base costs to personalize the economic analysis to determine which alternative most effectively reduces pollution and costs.

The following is a complete list of PPOs and alternatives presented in the Transportation Model Shop Report:

PPO	Alternatives
• Extend Engine Oil Change Intervals	Status quo: Change engine oil and oil filter on the TO driven schedule Alternative I: Perform in-shop engine oil analysis Alternative II: Implement laboratory oil analysis program Alternative III: Install engine oil bypass filters in conjunction with laboratory OAP
• POL Filter Handling	Status quo: Dispose used filters as solid waste without crushing them first Alternative I: Crush filters and recycle as scrap metal
• Extend Antifreeze	Status quo: Change antifreeze on TO or other time-driven schedule change intervals Alternative I: Perform antifreeze testing to determine need to changeout
• Antifreeze Recycling	Status quo: Dispose used antifreeze as hazardous waste Alternative I: Recycle antifreeze with a distillation unit Alternative II: Recycle antifreeze with a deionization unit
• Aqueous Based Parts Washing	Status quo: Clean parts in a solvent parts washer without filtration Alternative I: Clean parts in an automatic ("dishwasher") spray washer Alternative II: Clean parts in a sink-type heated aqueous parts washer
• Solvent Parts Washing with Solvent Filtration	Status quo: Clean parts in solvent parts washers without filtration Alternative I: Retrofit solvent filtration onto existing parts washers Alternative II: Use portable solvent filtration on several solvent parts washers Alternative III: New solvent parts washers with solvent filtration
• Solvent Recovery for Parts Washing	Status quo: Dispose of all used solvent as hazardous waste Alternative I: Decant solvents before disposal Alternative II: Distill used solvents on base
• Circuit Board and Small Part Steam Cleaning	Status quo: Clean circuit boards with aerosol solvent and paper towels Alternative I: Clean circuit boards with a steam cleaner
• Paint Gun Cleaning Alternatives	Status quo: Manually clean paint guns with solvent and dispose solvent as hazardous waste after one use Alternative I: Clean paint guns in closed-top paint gun cleaner Alternative II: Clean paint guns in closed-top paint gun cleaner with filtration
• HVLP Paint Guns	Status quo: Use existing conventional paint guns Alternative I: Purchase new HVLP paint guns
• Paint Gun with Paint Pot Liners	Status quo: Clean paint pots with solvent Alternative I: Use paint guns with paint pot liners
• Solvent Recovery for Paint Operations	Status quo: Dispose of all used solvent as hazardous waste Alternative I: Decant solvents before disposal Alternative II: Distill used solvents on base
• Plural Component Proportioning System	Status quo: Manually mix two part paints and dispose of excess Alternative I: Use plural component proportioning system
• Dry Filter Paint Booth	Status quo: Use water wall paint booth Alternative I: Use dry filter paint booth
• Depainting and Sanding Alternatives	Status quo: Use chemical paint stripping Alternative I: Use conventional blast media and dispose as hazardous waste Alternative II: Use conventional blast media and recycle the waste Alternative III: Use "sponge" blast media
• Stenciling Alternatives	Status quo: Spray paint stenciling Alternative I: Manually cut-out adhesive lettering Alternative II: Apply computer generated adhesive stencils
• Aerosol Can Alternatives	Status quo: Use standard aerosol cans and dispose as hazardous waste Alternative I: Deplete aerosol cans and recycle as scrap metal Alternative II: Use refillable pressurized cans for aerosol solvent
• Bulk Distribution	Status quo: Use small units of issue and dispense singularly Alternative I: Use large units of issue and distribute from bulk drum rack Alternative II: Receive products by tanker and pump from holding tanks

PPO	Alternatives
• Absorbent Usage / Spill Cleanup	Status quo: Use absorbent pads once and dispose "wet" with recovered liquid Alternative I: Compact absorbent pads prior to disposal Alternative II: Wring-out absorbent pads and reuse Alternative III: "Dry" absorbent pads in a cyclone and reuse
• Battery Operation Alternatives	Status quo: Use standard, flooded, lead acid batteries Alternative I: Use absorbed electrolyte, gel-cell, lead acid batteries
• Battery Desulfation	Status quo: Recharge batteries without desulfation Alternative I: Install solar desulfation units on individual vehicles Alternative II: Install a multiple-battery desulfation unit in the shop
• Alternative Fuels	Status quo: Use conventional fuel vehicles Alternative I: Convert conventional-fuel vehicles to CNG on base Alternative II: Send conventional fuel vehicles off-base for conversion Alternative III: Purchase originally CNG-powered vehicles

MANAGEMENT INITIATIVE / GOOD IDEAS

Ninety-two Management Initiatives and Good Ideas are identified in the Transportation Model Shop Report. These initiatives and good ideas do not include a detailed description of all alternatives or an economic analysis and can generally be implemented quickly with little or no capital investment. The Management Initiatives and Good Ideas were compiled from existing P2OAs, good ideas observed during the base visits, and ideas suggested on the World Wide Web or other P2 resource publications.

The Management Initiatives are overall recommendations that, if implemented, can contribute to waste reduction goals. The Good Ideas are organized by vehicle maintenance process, although some ideas relate to more then one process. In most cases when equipment or supplies are recommended, a vendor reference has been included.

The following is a list of Management Initiatives / Good Ideas presented in the Transportation Model Shop Report:

Process	Management Initiative / Good Idea
• Basewide	Implement / Participate in Hazardous Material Pharmacy Program Recycle Aluminum, Glass, Plastic, Paper, Cardboard, Etc.
• Engine Oil Changes	Send Used Oil to Be Re-Refined Use Re-Refined Oil Drain Oil Filters Burn Used Oil Filters for Energy Recovery Blend Used Oil with Diesel Fuel Avoid Contamination of Used Oil Collect and Redistribute Residual Oil Recycle Unserviceable 55 Gallon Drums as Scrap Metal Refill Empty Containers from Bulk Distribution System Drain Plastic Containers and Reuse/Recycle Use Synthetic Engine Oil
• Hydraulic, Transmission and Other Fluid Changes	Use Automatic Transmission Flush and Fill Machine Fluid Top-off in Lieu of Fluid Replacement Use Non-Ether Starting Fluid Perform Hydraulic and Transmission Fluid Testing Use Synthetic Transmission Fluid
• Antifreeze Changes	Purchase Recycled Antifreeze Substitute Ethylene Glycol-Based Product with Propylene Glycol Product Transfer Recycled Antifreeze to Bulk Distribution System Skim Oil from Antifreeze with Selective Absorbents Sell Recycled Antifreeze to Customers Donate Excess Recycled Antifreeze to Local Organization

Process	Management Initiative / Good Idea
• Parts Washing	Wipe Off Heavy Grease and Solids before Washing
	Clean Parts by Hand Whenever Possible
	Keep Parts Washer Cover Closed When Not in Use
	Extend Life of Contract Service to Replace Solvents
• Brake Maintenance	Recycle Shavings, Shoes and Pads
	Return Brake Shoes to Manufacturer/Distributor
	Use Vacuum Unit with HEPA Filtration
• Battery Maintenance	Use Maintenance-Free Batteries; Trade-Up with Manufacturer
	Recycle Unchargable Batteries
	Recycle Battery Cables
	Use a Ni-Cd Battery Reconditioner
• Tire Maintenance	Recycle Lead Weights and Tires through DRMO
	Reuse Lead Weights
	Repair Tires
	Sell Spent Tires to Road Paver
	Trade Tires with Manufacturer
	Purchase Unwrapped New Tires
	Purchase Retreaded Tires
• Air Conditioning Service	Retrofit Vehicles to non-CFC Refrigerants
	Recover all Refrigerant for Reuse
• Tune-ups, Lubing and Greasing	Recycle Spark Plug Wires
	Install Air Filter Element Protector
• Fuel Tank Maintenance/Fuel Filter Changes	Filter Contaminated Fuel for Reuse in Vehicles
	Reuse Fuel in Non-Mission Critical Vehicles
	Prevent Inadvertent Mixing of Fuels
	Install Diesel Gauge on Diesel Engines
• Paint Removal and Sanding	Use Media Blasting Rather than Chemical Paint Stripping
	Use Paint Preparation Booth With Air Filter
	Use Vacuum Sanders with HEPA Filtration
	Use Portable Air Cleaners Where Vacuum Sanders Not Practicable
	Perform "Paintless" Body Work
• Painting	Schedule Painting by Color
	Reuse Masking Material and Patch Floor Masking
	Masking Alternatives
	Provide Personnel with Painting Training
	Use Excess Paint as Base Coat for Subsequent Jobs or as Undercoat
	Reblend Old Paints through Contractor
	Mix Paints with Mechanical Shaker
	Make "Safe and Serviceable" the Goal for Vehicle Upkeep
	Change Paint Booth Filters Based on Differential Pressure
	Investigate Alternative Painting Methods
	Use Water-Based and Low-VOC Paints
	Recycle Paint Cans
	Consider Extending Service Intervals on Contract Removal Service
	Use Multiple-Stage, "Step-Down" Cleaning Method
• Refueler Vehicle Maintenance	Change Fuel Filter Based on Differential Pressure
• Vehicle Washing	Install Wash Water Recirculation System
	Use High-Pressure Hoses with Automatic Shut-Off Nozzles
	Use Non-Phosphate, Biodegradable Surfactant Formulation Detergents
	Only Use Approved Wash Racks

Process	Management Initiative / Good Idea
• Rags and Absorbents	Reuse Absorbent Material with Multiple Stage Storage Segregate Segregate Used Absorbents by Material Absorbed Use Lightweight Absorbents to Minimize Weight of Waste Purchase Pads Composed of Recycled Materials Use Laundering Program Launder and Reuse Coveralls Rather than Using Disposables Launder Rags In-House
• Spill Prevention	Use "Oil Caddies" or Drip Pans Reduce Intermediate Steps in Material Transfers
• General Facility Maintenance	Reuse or Recycle 55-Gallon Drums, Overpacks, Containers Install and Properly Maintain Oil/Water Separators Reuse/Compost Wood Pallets Minimize Water Usage with Recycling Floor Scrubber or Mop and Bucket Skim Oil from Wash Water with Preferential Absorbent Attach Catch Pans to Detroit Diesel Buses for Oil Drippage Replace Lifts Having USTs for Hydraulic Oil
• Fire Truck AFFF System Maintenance	Remove AFFF Before Bringing Into Shop Use Contaminated AFFF for Fire Department Exercises

AFFIRMATIVE PROCUREMENT / PRODUCT SUBSTITUTION

A section providing recommendations and information pertaining to Affirmative Procurement and Product Substitution is also included in the Transportation Model Shop Report. Product Substitution includes recommendations for the replacement of hazardous chemicals currently being used in vehicle maintenance processes with an environmentally friendly alternative. Attention has been given to replacements for Ozone Depleting Chemicals, EPA 17 Industrial Toxic Pollutants, and Toxic Release Inventory chemicals. Appendix A of the Transportation Model Shop Report presents a list of Product Substitution Data for easy identification of environmentally preferable products.

Affirmative Procurement is the selective acquisition of products containing recycled and reclaimed materials to replace products manufactured from raw materials in response to Executive Order 12783, "Federal Acquisition, Recycling and Waste Prevention". Purchasing reasonably priced items made from recycled materials reduces the demand for virgin feedstock, aids in slowing the filling of solid waste landfills, and reduces reliance on foreign raw materials, such as crude oil.

SUMMARY

The Transportation Model Shop report was created to reduce base efforts for identifying and implementing pollution prevention opportunities for vehicle maintenance processes. AFCEE recently contracted with Parsons ES to update the report to include technological advancements and more detailed descriptions. The Transportation Model Shop Report is a valuable tool for vehicle maintenance personnel and environmental managers for finding environmentally friendly and cost-effective alternatives.

Copies of the Transportation Model Shop report are available from the AFCEE Program Manager and PRO-ACT:

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SESSIOIN XX
P^2 MANAGEMENT TOOLS

SESSION CHAIRPERSONS:

Ms. Rosie Ramirez, HQ AFCEE/JA
Mr. Randy Griffith, Tetra Tech

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AIR COMBAT COMMAND HAZARDOUS MATERIALS MANAGEMENT PROCESS TEAM SUCCESS

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ABSTRACT

HQ Air Combat Command (ACC) demonstrated teamwork at its best by forming a successful Hazardous Materials Management Process (HMMP) Team. A diverse representation of command directorates, the group formed to create an ACC supplement to the new Air Force Instruction (AFI) on Hazardous Materials Management. With unique perspectives, each member expressed concerns over how ACC would best implement the processes and fulfill the objectives set forth in the AFI.

The challenge was to work together for the common goal of reducing hazardous material usage while accomplishing the Air Force mission, and with consideration to various organizational constraints. After obtaining everyone's buy-in to the overarching goal of hazardous material reduction, the team then agreed on the specific issues to address, identified potential solutions, negotiated the preferred solution, and then formulated command policy that was workable for every organization represented. The team emerged as a unified body with a strong Hazmart policy built upon genuine consensus.

BACKGROUND

In 1993, the Air Force mandated that its bases institute Hazmarts, or hazardous material pharmacies, for tracking, distributing, and controlling hazardous materials. A well-operated Hazmart reduces hazardous waste generated on a base and ensures that the hazardous materials used on a base are managed responsibly. The Hazmart concept brought environmentally positive changes to Air Force bases. However, since its inception, the Hazmart has been accompanied by confusion and misunderstanding. While bases were eager to reap the environmental benefits of the Hazmart, putting new practices in place created challenges. Bases lacked manpower, guidance, and funding. Consequently, Hazmart operations differed from base to base without firm direction or a standard approach.

On 1 August 1997 the Air Force issued AFI 32-7086, *Hazardous Materials Management*, that governs the management of hazardous materials. The AFI sought to standardize responsibilities and procedures throughout the Air Force. We at ACC then sought to create a

command-specific supplement to the AFI, and in the process resolve Hazmart problems and streamline operations while optimizing effectiveness and efficiency.

TEAM PROBLEM SOLVING

When ACC embarked on the task of supplementing the AFI, we were challenged to develop useful Hazmart guidance to the 18 ACC bases. Staff members from all the affected organizations agreed that the AFI left some Hazmart issues unresolved. With that understanding and in compliance with the AFI, the command formed their HMMP Team.

Our team's first order of business was to develop an HMMP Team Charter. This charter determined team membership (eight member and nine associate member organizations), meeting frequency (quarterly), and method of decision-making (consensus of membership). It established the team's key result area of reducing hazardous waste. The charter also created two subordinate working groups: 1) Hazmart/Sources of Supply Working Group, and 2) Hazardous Material Reduction Prioritization Process and Ozone Depleting Substance Management Working Group.

The next step was to obtain everyone's buy-in to one overarching goal: to control and reduce hazardous material usage and all its associated costs. This was fairly straight-forward due to the existing guidance in the AFI.

Pinpointing the most pressing problems to address first was the team's next task. The team decided to tackle the following issues: 1) How do we control hazardous material IMPAC (International Merchant Purchase Authorization Card) purchases? 2) How do we define free issue? 3) Who establishes ACC Hazmart policy? 4) How do we resolve decentralized versus partially decentralized Hazmart operation? This last issue was a result of the AFI stating the Air Force standard was a partially decentralized operation. ACC Supply preferred a decentralized operation and base Hazmarts were operating at various points on the spectrum between centralized, partially decentralized, and decentralized.

After reaching agreement on what the problems were, we then brainstormed all possible options for each problem. This was accomplished by maintaining an open mind and without criticizing or evaluating the proposed alternatives. The next step was to narrow the options list to those that were acceptable and doable. For example, if an option was totally unacceptable to one of the impacted organizations, or did not comply with the AFI, it was eliminated. Subsequently, the team objectively identified the pros and cons for each remaining alternative.

At this point, the team faced their biggest challenge: reaching consensus on the preferred solution to each problem. This was complicated by the internal goals of one organization sometimes conflicting with the internal goals of another organization. For example, Base Supply owns and operates the Hazmart, which is the base central focal point for hazardous materials, and supply provides most of the manpower for operating the Hazmart. Yet it is Civil Engineering (CE) who is responsible for the base's hazardous waste management and pays for all waste disposal, and proper control and management of hazardous materials greatly impacts the generation of hazardous waste. In addition, CE is dependent on the Hazmart for data in order to accomplish required environmental reporting. Consequently, CE has a serious stake in the effectiveness of the Hazmart operation. Yet supply was paying the Hazmart manpower bill, for the most part without any CE manpower, and supply was (and still is) in the midst of a major downsizing effort. Putting an innovative, interdependent program into practice put cooperation skills to the test.

All four issues were resolved - the final product being a joint CE/Supply policy memorandum. This memorandum is a statement of ACC policy outlining each issue and providing coordinated, cross-functional direction. This was achieved by team members closely listening to each organization's perspective, understanding the various internal organizational limitations, conscientiously determining the intent of the AFI, and then creatively developing a compromise that was workable for all parties. This policy memorandum is a valuable tool for our ACC bases to operate a successful Hazmart program.

RESULTS

The resolution of the four issues addressed in the policy memorandum are:

1. *Free Issue* - The Hazmart will operate a free issue program as required by the AFI. The free issue area will accept unopened or partially filled hazardous material (HM) containers if it meets the following criteria: (1) is certified as uncontaminated by the original customer, (2) was originally issued by Supply or IMPAC purchase, (3) has at least six months remaining on its shelf life, (4) has more than one user, (5) has a readable label, and (6) has a Material Safety Data Sheet (MSDS). The Hazmart supervisor may waive any of the above criteria. Other sources of supply, e.g., CEMAS, COPARS, MEDLOG, are responsible for managing their own free issue program.

2. *IMPAC Purchases* - We concluded that with internal controls, well-defined procedures, strict enforcement, and education and training, we can manage these purchases. The team developed the following rules:

a. HM IMPAC purchases will be restricted to a limited number of individuals in each unit who are "certified". Every squadron commander will authorize those in his/her unit to buy HM with the IMPAC. These individuals will receive additional IMPAC training and on completion of this training, they will receive certification to purchase HM. The unit environmental coordinator and safety representative will also work closely with these HM purchasers to ensure they are knowledgeable about what they are buying.

b. The Hazmart should be the first stop for the customer to initiate an AF Form 3952 (HM Authorization Form) and the user must obtain approval from Bioenvironmental Engineering (SGPB), CE, and Safety on the form. Electronic AF Form 3952s are the preferred method of submission and coordination. Electronic signatures are acceptable for the approval process. The Hazmart will enter the AF Form 3952 data into EMIS (Environmental Management Information System). After the HM is bought, the user will notify the Hazmart of what was purchased and the Hazmart will enter the transaction data into EMIS and provide the barcode number to the customer. It is not mandatory to actually place the barcode label on HM containers. When CEMAS and COPARS supply systems are used, those organizations (CE and Transportation) are responsible for ensuring an AF Form 3952 is completed and the form and transaction data are entered into EMIS. When MEDLOG supply system is used, SGPB will ensure HM purchases of non-medical items are entered into EMIS. The user is then responsible for "closing the loop" on their HM usage. The user will go to the nearest EMIS terminal to complete three EMIS data fields (CSA number, Barcode number, Returned) to document what happened to the material. Until that step is done, they will not be authorized to purchase more of that HM.

c. Holders of the IMPAC permitted to buy HM will be held accountable for all HM purchases made with their card. If purchases are made that are not authorized, or are not reported

to the Hazmart or other source of supply as required, appropriate penalties will be imposed. These penalties will be of sufficient consequence to prevent recurrence.

d. Properly educating HM IMPAC users on the procedures to follow, the importance of minimizing HM usage and reducing the number of different products purchased, is key to the success of this process.

3. *ACC Hazmart Policy* - In accordance with the AFI, the cross-functional ACC HMMP Team establishes Hazmart policy. All policy that impacts Hazmarts will be coordinated through this team.

4. *Decentralized or Partially Decentralized* - ACC will operate as partially decentralized in accordance with the AFI. There will be a separate facility known as the Hazmart, which consists of a HM storage area, a free issue area, and an office with EMIS terminals. It will provide a central point of control for HM users. However, the demand processing, stock control, receiving and delivery functions of supply need not be physically located in the Hazmart. The Air Force standard of a partially decentralized operation may be exceeded (i.e., be more centralized) if the installation provides the additional manpower required.

CONCLUSION

As a result of genuine teamwork, ACC's HMMP Team has set a standard for cooperative management in developing solutions to problems that are acceptable to all participants, regardless of various independent organizational goals and constraints. The team continues to improve hazardous material management command-wide. For the ACC 1998 Environmental Training Symposium, the HMMP Team developed a joint Hazmart briefing that provided clarification on additional issues of concern to our bases. The ACC Supplement to the AFI, which sparked the need for this entire process, is in final coordination with publication expected in Sep 98. This supplement further defines procedures, sets standards, and provides guidance for all ACC installations.

REFERENCES:

1. AFI 32-7086, *Hazardous Materials Management*
2. HQ ACC Hazmart Policy Memorandum, 22 Dec 97
3. Draft ACC Supplement 1 to AFI 32-7086

HEADQ

UARTERS AIR COMBAT COMMAND
ENVIRONMENTAL QUALITY HANDBOOK – PROGRAM GUIDANCE FOR THE 21st CENTURY

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INTRODUCTION: Headquarters (HQ) Air Combat Command (ACC), Environmental Compliance Branch first published the Environmental Compliance Handbook in February 1996. The handbook consolidated HQ ACC policy/guidance to achieve and sustain environmental compliance. A subsequent July 1996 update expanded the handbook by addressing current compliance concerns like Underground Storage Tank (UST) management, Polychlorinated-Byphenols (PCB) disposal, Aerospace National Emission Standards for Hazardous Air Pollutants (NESHAP), environmental incident investigation, environmental partnering, open burn/open detonation permit closure, and Resource Conservation and Recovery Act (RCRA) Corrective Actions (RCA). The third edition of the handbook published on 5 September 1997 and available on CD-ROM reflects the Air Force initiative to incorporate Pollution Prevention (P2) as a method to achieve compliance. A chapter is devoted to pollution prevention along with updates on a number of important environmental compliance issues relative to ACC base level environmental management. This paper presents an overview of significant policies and guidance found in the 5 September 1997 issue of the Environmental Quality Handbook.

The Environmental Quality Handbook is a consolidated tool for installation managers to understand policies and guidance regarding environmental compliance through P2. Although only covered in this paper in an abbreviated form, program managers can see where emphasis should be placed to meet regulatory compliance. Maintaining full compliance with all regulatory programs does not happen by chance. Through the dedicated efforts of many environmental professionals using tools like the ACC Environmental Quality Handbook, installations can continue to deliver world-class environmental programs.

THE CHALLENGE: Zero enforcement actions has become a byword of the Air Force environmental manager. While regulatory agencies utilize the Notice of Violation (NOV) as an administrative process, the Air Force has made these administrative non-compliance procedures a measure of merit. The NOV is used to gauge the environmental performance of entire installations and Commands. In fact, the entire Air Force seems focused on this singularly,

sometimes minor, event as a test of environmental success. While environmental professionals understand there is much more to successful management than achieving zero enforcement action, today's challenge is to sustain an environmentally compliant mission within the current funding climate.

The following summary of environmental compliance and P2 policy and guidance concentrates on balancing these two opposing philosophies, achieving zero enforcement actions and keeping costs low. Locating a happy medium is a challenge and one that must be achieved if the mission is to be effectively executed. Zero enforcement is best achieved by diligent and constant effort by dedicated, knowledgeable environmental professionals.

RESOURCE CONSERVATION AND RECOVERY ACT: The Resource Conservation and Recovery Act (RCRA) was passed in 1976 and established the statutory requirements that are the basis of the Hazardous Waste (HW) regulations. In 1984 Congress passed the Hazardous and Solid Waste Amendments (HSWA) which required the Environmental Protection Agency (EPA) to establish regulations applicable to Underground Storage Tanks (USTs) and the corrective actions program. Both of these regulations have had significant and costly impacts on the Air Force. Some of the RCRA updates to the handbook reviewed below include the UST and RCA site clean-up programs. Other areas addressed are HW training, the RCRA air emissions standard rule, fuel tank water bottoms disposal, Part B Permit elimination, and HW management while deployed.

USTs are defined at 40 CFR §280.12 as "any one or combination of tanks (including underground pipes connected thereto) that is used to contain an accumulation of regulated substances, and the volume of which (including the volume of underground pipes connected thereto) is 10 percent or more beneath the surface of the ground." By 22 December 1998 USTs greater than 660 gallons which are leak free must have leak monitoring, spill/overfill prevention, and cathodic protection. Leaking USTs will be removed. Replacement tanks must be aboveground, or underground tanks will be in vaults, or double walled in accordance with state and local regulations. It is ACC's policy to apply this same strategy to unregulated USTs (e.g. heating oil tanks), although this requirement is a low funding priority. Every ACC base should have a completed UST inventory, have completed upgrades or have projects programmed to complete upgrades by the deadline.

Resource Conservation and Recovery Act (RCRA) Corrective Actions (RCA): For those bases with Part B permits, RCA should be an important part of your RCRA management program. Authority for implementation of this program is the 1984 amendments to RCRA called the Hazardous Solid Waste Amendments (HSWA). It mandates each regulatory agency include as part of RCRA permits a Corrective Action Management plan (CAMP). The CAMP must also include a schedule for sites where releases of contaminants are suspect or documented. This will sound familiar to the environmental restoration staff at ACC bases. It is similar in that it regulates clean-up of contaminated soils similar to Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Superfund. The big difference comes in control of the clean-up process. Under CERCLA owners propose solutions and advise regulatory agencies of their plan of action. In RCA the owners propose solutions and the regulatory agency

approves their plan of action. Additionally, under RCRA the installation is susceptible to fines and penalties. Obviously management of Air Force sites under CERCLA is the preferred approach.

Implementation of RCA has begun at ACC bases. The handbook provides reference to an important implementation tool that will yield considerable savings to the Air Force. That tool is the use of the American Society for Testing and Materials, standard E 1739-95. This standard is titled, Risk-based Corrective Actions (RBCA) (pronounced Rebecca). Each RCA program manager should be familiar with this standard and apply it at appropriate sites to mitigate financial impacts to installations while maintaining full compliance. ACC estimates a $57 million cost avoidance is possible over a six-year period using risk-based clean-up standards.

Hazardous waste training is broken down into Levels I, II and III. Level I is required for all personnel, and their supervisors, who, although they do not handle hazardous waste on a regular basis, are reasonably anticipated to encounter it during the course of their duties. This category includes commanders and public affairs personnel. The training consists of an overview of HW issues including roles and responsibilities, emergency response/spill response, safety and P2. Level II or operational training is required for all personnel, and their supervisors, who work with hazardous waste on a regular basis. A standard Level II training session should last one to three hours. Level III training or regulated training is required for all personnel, and their supervisors, who work in 90-day accumulation points, or at interim status or permitted Treatment, Storage and Disposal (TSD) facilities. The desired learning objectives are listed in the handbook, pages 3-12. These objectives should help managers and operators understand the importance of characterizing waste prior to disposal, proper disposal procedures, satellite accumulation point management and hazardous waste storage to mention a few. These are just a sampling of the areas where enforcement actions have been active within ACC. Refresher training for all three levels is required annually. Installation managers will also find the "Hazardous Waste Compliance Assessment" dated June 1995 and prepared for ACC by Oak Ridge National Laboratory, a valuable and easy to read resource of HW terminology and key performance areas. The most valuable part of this training tool is the activity-specific guidance on assessing compliance. Achieving HW management compliance requires an effective HW training program. The newly released Air Force CD ROM version of desktop HW training can be utilized to fulfill the training requirements outlined above.

The RCRA air emissions standard became effective in December 1996 and a final rule clarification published 8 December 1997. The rule establishes standards for the control of volatile organic compound emissions from tanks, surface impoundments, and containers at TSDs and 90-day accumulation points. In ACC we do not have any volatile organic waste in surface impoundments or tanks, so the recycling and treatment might be the only area of concern. Containers are excluded if they have a design capacity less than about 26 gallons, are used to store HW at satellite accumulation points, or are used by small quantity generators to store on-site for less than 180 days. Potential areas of concern within ACC could be aerosol can crushers or solvent stills. By using Department of Transportation (DoT) approved containers which provide a "cover" that forms a continuous barrier over the waste and meets the requirements of a closed container under RCRA, the specific requirements of this rule can be met.

Fuel tank bottom water resulting from condensate in petroleum storage tanks typically tests positive for the presence of benzene. Hence it must be disposed of as HW. However, you may be able to manage it as a domestic sewage, pass it through a sewer system to a Publicly Owned Treatments Works and, therefore, not be a solid waste as defined by RCRA. Another option is to pretreat the water, removing the benzene and then discharge to the sanitary sewers. This latter provision must be accomplished under provision of the Clean Water Act (CWA) and the installation National Pollution Discharge Elimination System (NPDES) permit. Ellsworth AFB has installed a pretreatment system on their bulk storage tanks that is successfully meeting their regulatory discharge and disposal requirements and saving HW process costs.

Eliminating Part B RCRA permits is an objective of ACC. Environmental permit elimination is also being considered for an Air Force measure of merit. One way to reduce environmental oversight and liability is to reduce the HW handled. Most ACC installations have streamlined their hazardous waste management to the point it may be possible to eliminate the greater than 90 day storage facility. This permitted facility is usually located at the Defense Reutilization and Marketing Office (DRMO) and authorized via a RCRA Part B permit. The regulatory requirements for a Part B permit are specific and often onerous. Eliminating this permit will enable base managers to focus on improving other important hazardous waste management functions. As a matter of interest, Defense Reutilization and Marketing Service (DRMS) recently announced the projected closure of DRMOs at four ACC bases. This may fuel the motivation to act quicker to complete RCRA permit closures at the affected bases. Another way to reduce the need for a permit is to reduce HW. One way to do this is to use the Hazmart facility, a program for tracking the distribution and use of hazardous materials on a base. The system tracks materials from the Hazmart warehouse to the shop, and then back to the warehouse for reissue or proper disposal.

Management of hazardous waste for deployed units is an area of particular concern within ACC. Air Force policy is to be responsible environmental stewards while operating at deployed locations. Units deployed to CONUS facilities coordinate HW management with the host facility prior to deployment. One option to handle generated HW is to manifest the waste and ship it to a storage facility. For overseas deployment the unit prepares an environmental annex to their deployment plans. The specifications of this plan are outlined in JCS publication 4-04, "Joint Doctrine for Civil Engineering Support." At minimum, ACC units have sufficient HW collection materials for the first three weeks of deployment to include a spill kit of sufficient size to handle small releases. HQ USAF/ILEV published a handbook for contingency operations in August 1996 which provides helpful ideas on environmental issues while deployed. The ACC handbook contains a matrix for managers use to determine actions installation agencies might take prior to, upon arrival at, and post deployment to meet environmental minimum essential requirements.

CLEAN AIR ACT: The significant Clean Air Act (CAA) issues impacting ACC bases include final approval of Title V operating permits, complying with Aerospace National Emissions Standards for Hazardous Air Pollutants (NESHAP), and compliance with future NESHAPs. The 5 September 1997 handbook update provides a description of key responsibilities for base level

and Command air quality managers and discusses the Volatile Organic Compound reduction goal for the Command. A summary follows:

Title V operating permit applications for most ACC installations have been submitted to state regulatory agencies. These permits establish specific operating conditions that must be followed by various base organizations. Organizational paint shops, specifically aircraft corrosion control, are potentially impacted by Title V permit operating conditions. Air managers should be familiar with the provisions of their operating permit and establish procedures to maintain full compliance. While the application is waiting approval the installation is operating under a permit shield. Once the state regulatory authority approves the permit the installation must operate in full compliance with the conditions spelled out in the permit. For many of our bases it is essential these permits are issued to establish Federally enforceable emission limits. This becomes critical to achieve compliance with the Aerospace NESHAP rule as proof of status can only be verified through Federally enforceable permits.

The Aerospace NESHAP rule promulgated by the Environmental Protection Agency (EPA) in September 1995 allows aircraft maintenance activities, which are major hazardous air pollutant sources, until 1 September 1998 to achieve compliance. Specific requirements vary with the maintenance activity, but generally the aircraft corrosion control facility will be the most impacted of any operation on the base. ACC bases are striving to achieve minor Hazardous Air Pollutant (HAP) source status by obtaining Federally enforceable permit conditions which limit operations to keep emissions below the major source designation. There is one exception that could apply to many installations which is called the EPA Transition Policy. This policy says if you can prove your actual emissions are 50% or less than the 25 tpy for total HAPs and 10 tpy for any single HAP, you are not a major source. That means if you can prove your actual emissions are below those levels, you don't have to get Federally enforceable limits before you're Title V permit. Per HQ EPA telecon, 28 May 1998, the transition policy is being extended until the potential to emit rule is final. The transition policy will help many ACC bases achieve compliance with the Aerospace NESHAP rule even though their Title V permits have not been issued.

There are a number of upcoming NESHAPs that may impact ACC installations. The EPA is mandated to publish these NESHAPs over the next several years while others have already been published. For example, the woodworking NESHAP restricts emissions from varnishes and lacquers from wood hobby shops. Other NESHAPs to watch include boilers, jet engine testing, and emergency generators.

Each ACC installation is required to prepare a Halon Management Plan plus all facility fire suppression Halon systems must be placed on manual operation. Halon tanks must be leak-tested semi-annually. Halon portable fire extinguishers will be used only in mission critical applications. Effective 1 April 1994, the purchase of Ozone Depleting Substance (ODS) solvents and equipment, systems, and products requiring ODS solvents for maintenance or operation is prohibited without approval.

CLEAN WATER ACT: Updates in the handbook for Clean Water Act (CWA) include the review of responsibilities at HQ and base level, inflow and infiltration assessment progress, a discussion of 40 CFR 503 the sludge rule, stormwater updates, organization car washes, oil water separators for jet engine test cells and deicing management. While no updates were provided on the Safe Drinking Water Act (SDWA) it is appropriate within this paper to review some recent findings of concern relative to water quality.

Inflow and infiltration (I&I) within installation sanitary systems have been found at all ACC bases. Inflow is storm water that rapidly enters sanitary sewers through illicit roof and area drain connections, storm sewer cross-connections, and defects in sewer lines, manholes and manhole covers. Infiltration describes water entering a sewer system from indirect flow of stormwater and groundwater into the sanitary sewer. Examples include leaking joints, misaligned service connections and tree roots. Effective environmental wastewater programs assess the I&I of bases systems to ensure compliance with provisions of the CWA and NPDES permits.

The sludge management regulatory requirement is found in 40 CFR 503, the Federal Standards for the Use or Disposal of Sewage Sludge. This standard "establishes requirements for debris collected in the preliminary treatment phase at a Wastewater Treatment Plant (WWTP) pollutant limits, management practices, and operational standards for the final use or disposal of sewage sludge generated during the treatment of domestic sewage in a treatment works." Section 503 includes regulations pertaining to sludge quality, method of application, and general and managerial requirements associated with various sludge quality and use/disposal scenarios. Land disposal on ACC bases is at the discretion of the installation commander.

The EPA has chosen the Storm Water Pollution Prevention Plan (SWP3) as their tool for implementing the storm water program. The key components of this plan are: planning and organization, assessment phase, best management practices identification phase, implementation phase, evaluation and monitoring. In order to develop an effective SWP3 thorough assessment for all pollutant sources is required. This includes an inventory of all exposed significant materials, a list of significant spills and leaks, and testing for illicit connections or non-storm water discharges. Illicit connections refer to any source of non-storm water flow which discharges from the base. Three types of permit options exist for industrial storm water permit, individual, general, and the multi-sector general. All ACC bases applied for the Group permit, many have opted out of the group permit and now have individual, or baseline general permits. An effective program includes good housekeeping, preventive maintenance and monthly visual inspections. SWP3 team members conduct annual site evaluations.

The stormwater phase II rules have potential for impacting ACC installations significantly. The CWA Stormwater Rule expands to non-industrial areas. The first phase included industrial areas and ACC bases have prepared SWPPPs with Best Management Practices (BMPs) to comply with the rule. The EPA is now under court order to finalize the Phase II rule by 1 Mar 1999. This rule will regulate military bases along with municipalities less than 100,000 people. This includes stormwater runoff from construction sites one to five acres and may regulate accumulative disturbances of these sites over time. It will also regulate non-point source runoff (e.g. golf courses, construction sites, agricultural areas), will establish total maximum daily loads

or not to exceed contaminant levels, and will require stormwater mapping of areas (e.g. residential and golf courses). Within ACC the use of GIS systems may be appropriate to meet this requirements. Although the deadline is not published yet, environmental managers can expect a deadline 30 months after final rule or about August 2001. Non-structural BMPs will have to be implemented immediately which will include things like, sampling, monitoring, and management actions

Organizational car washes are held to the same stormwater discharge standards as the rest of the base. Effluent from an organizational car wash with the potential to enter the waters of the U.S. needs to be captured and treated or discharged via a NPDES approved discharge point. Operation of car washes should capture and discharge wastewater to a sanitary sewer.

Oil Water Separators (OWS) for jet engine test cells generate a significant quantity of waste Petroleum Oil and Lubricant (POL) products. These waste POL products often find their way into the existing sanitary sewer collection system. It is ACC policy to not construct new OWSs , remove existing systems if possible, or upgrade to more efficient technologies. Use of closed looped washwater reuse systems is acceptable but not always desired because of high O&M costs.

The Air Force Deicing management program organized a tiger team of MAJCOM representatives which developed criteria for prioritizing projects to correct deicing problems. The Air Force Deicing/Anti-Icing Stakeholder's Installation Prioritization Decision Model was developed for this purpose. Implementation of the suggested management practices involves many organizations to ensure run-off reductions and prevent future regulatory actions.

The SDWA amendments signed into law 6 August 1996 substantially change many aspects of the requirements of the Act. ACC has undertaken a comprehensive review of drinking water quality systems to ensure ACC installations identify and correct deficiencies. Compliance investigations to date have found significant problems including cross-connections, back-flow prevention device failure, biological film build-up and ground water under the direct influence of surface waters. Water managers are programming both environmental and facility infrastructure maintenance and repair projects to correct problems.

TOXIC SUBSTANCE AND CONTROL ACT (TSCA): This chapter of the handbook covers asbestos management, PCB issues, lead-based paint and radon. Updates to the asbestos and PCB sections provided with the 5 September 1997 handbook include:

Asbestos enforcement actions continue to plague the Command and often include violations caused by contractors. From 1993 through 1996, ACC averaged one asbestos NOV per year. Appropriate specifications must be written which include minimum qualification and performance standards for compliance with TSCA and the CAA. Many asbestos violations actually are citations from the CAA provisions 40 CFR 61.145, Standard for Demolition and Renovation. The bottom line is the Air Force is responsible for asbestos compliance. The handbook outlines some key areas to watch in contractor removal of asbestos as well as minimum training requirements for personnel. Awareness training should be provided to anyone

who, in the course of their daily activities, might encounter asbestos containing materials. This should include most maintenance personnel and potentially those personnel who prepare vehicles for target use at ACC bombing ranges. Asbestos and operation management plans are also required at all ACC bases.

The Air Force PCB goal established in November 1995 was to be "PCB free" by December 1998. This goal includes removal of transformers and large capacitors contaminated with PCBs. As the Command approaches the December 1998 deadline there are only 20 transformers/capacitors at three ACC bases with PCB items that require action for closure. As a matter of interest, some USTs have been found within ACC which had coal tar protective coatings which contained PCBs. Environmental program managers should test any USTs removed that was manufactured prior to 1982 and has a coal tar exterior protective coat. Other PCB items such as contaminated light ballast not in the Air Force definition should be removed or disposed according to TSCA.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT: There are eight sections of the statute which require action by base environmental managers. The following is a very brief synopsis of the key elements of this law and environmental managers should refer to their state or EPA regulatory agency for local regulatory requirements.

The responsibilities of section 301 include primarily participation with the installation's Local Emergency Planning Commission (LEPC) or State Emergency Response Commission (SERC). This is typically accomplished through cooperative emergency response agreements. Section 302 requires a compilation of all extremely hazardous substances (see 40 CFR 355, appendices A and B) that exceed a specified threshold be notified to the LEPC and SERC. For ACC bases applicable chemicals have typically included chlorine, hydrazine, and toluene. Section 303 requires the LEPC to prepare an emergency response plan for the community. As a local facility, the base is expected to take part in the preparation of this plan along with the annual review. Under certain circumstances releases must be reported to your local LEPC under section 304. Training requirements must meet section 305 minimums for emergency responders.

Sections 311 and 312 outline reporting requirements for extremely hazardous substances and hazardous chemicals. The base supplies Material Safety Data Sheets for any extremely hazardous substance that meets or exceeds 500 pounds or the threshold planning quantity or any OSHA hazardous chemical (29 CFR 1910.1200(c)) that meets or exceeds 10,000 pounds, to the LEPC and the SERC. Section 313 reporting requirements are accomplished on the Toxic Chemical Release Forms(Form R). A Form R is required for listed chemicals manufactured or processed in excess of 25,000 pounds, or used in excess of 10,000 pounds.

SPILL REPORTING: Updates in the spill management chapter of the handbook cover two new areas; chlorine chemicals and aircraft accidents. No changes to spill reporting requirements to the HQ were made. WIMS-ES system is no longer used for spill reporting. ACC bases should primarily use the Air Force operational reporting system through their local wing command post and make reports to HQ ACC/CEVQ and the appropriate regulatory agency.

Chlorine and chlorine precursor chemicals (calcium hypochlorite and sodium hypochlorite) are used primarily as disinfection agents in swimming pools, water treatment plants, wastewater treatment plants, and in households. Chlorine is a poison gas and extremely irritating to the eyes and respiratory tract. Chlorine and chlorine precursor chemicals are listed under EPCRA (40 CFR 355) as extremely hazardous substances. They are also a hazardous substance under CERCLA (40 CFR 302.4) with sodium hypochlorite (Chlorox) having a reportable quantity of 100 pounds, and calcium hypochlorite (bleaching powder) a reportable quantity of 10 pounds. A release of these materials must be managed and reported in compliance with these acts.

ENVIRONMENTAL INCIDENT INVESTIGATION BOARD (EIIB): The purpose of the EIIB program is threefold: investigation, distribution of lessons learned and prevention. Environmental incidents are investigated to determine their causes and identify corrective actions to prevent recurrence of similar incidents. The level of investigation required is determined by the relative seriousness of the incident. There are four categories of investigations: categories 1, 2, 3 and 4. The wing commander ultimately must decide what category of investigation must be pursued and the handbook offers a guide to assist the commander in making this decision. The important change with this update of the handbook was effective 8 May 1997 when the ACC Environmental Leadership Council (ELC) approved EIIB investigations and reporting of petroleum releases up to 1500 gallons are optional at the discretion of the Wing Commander. This limit does not change regulatory reporting requirements of an installation.

ENVIRONMENTAL COMPLIANCE FUNDING: The most important tool for the base environmental manager relative to funding issues are appendices J and K. These outline in detail the eligibility requirements for compliance and pollution prevention funds. The new appendix K, pollution prevention funding matrix, identifies significant HQ USAF/ILEV changes regarding P2 eligibility. The important message is Air Force intent to migrate to a P2 mindset and reduce overall compliance costs. The P2 matrix reflects this strategy and encourages pollution prevention investments in achieving compliance through pollution prevention initiatives. HQ ACC Environmental Programs Division validations for environmental and P2 funds strictly follow the matrixes in the handbook.

The other important addition to this issue of the handbook was the inclusion of Defense Energy Fuels Supply Center (DESC) (formerly DFSC) funding guidance. Funding for environmental projects can be obtained for projects provided the requirement: 1) concerns fuels (JP-8 and some ground fuels) managed by DFSC, 2) involves maintenance and repair work including cathodic protection and secondary containment related to DFSC fuel systems, 3) is required for environmental compliance, or 4) consists of spill cleanup after 1 October 1992 of a DFSC fuel system. Emergency spill cleanup funds can be obtained from DFSC by immediately notifying HQ ACC/CEOI and following up with a spill report and project document , DD Form 1391.

The procedures for obtaining DESC funds are outlined in detail in the handbook. Call letters for DESC projects are sent to ACC installations two years prior to the program year and are typically due in October. Projects are programmed using a DD Form 1391 which is submitted to HQ ACC/CEPD. HQ ACC/CEO submits the project to DESC who authorizes design. The

installation requests design funds from HQ ACC/CEO. Upon design completion the installation requests contracting authorization and upon approval executes the construction project.

CONTRACT SUPPORT: The Environmental Compliance and Analysis (ECAS) contract has been a success for the Command. It has provided easy access to quality environmental services. Recent updates to the handbook review the requirements for delivery order package development and technical project manager responsibilities. If an installation wants a delivery order fast, it can be delivered through ECAS. ACC's ECAS technical project managers can also assist base managers in preparing a Statement Of Work and negotiating the delivery order. There are no fees for these services. Installations may execute a centralized or decentralized delivery order. Installation comments on the success of each delivery order help ensure contracts are responsive to the need of each program manager and help the contractors identify improvement areas.

ENVIRONMENTAL MILCON: Environmental MILCON projects must undergo the same scrutiny of review as other MILCON projects as described in AFI 32-1021 plus they must be Level I environmental non-compliance requirements. Also, the projects must be work classified as "construction." Repair and maintenance projects generally are not supported in the environmental MILCON program. Competition for environmental MILCON dollars is very vigorous. Projects will be viable only if they clearly and consistently document environmental non-compliance with regulatory requirements. Sporadic or occasional non-compliance excursions have not been generally accepted.

PARTNERING: It is the responsibility of Air Force leaders and environmental managers to establish a solid working relationship and rapport with Federal, state and local regulatory agencies. Most regulatory agencies are receptive to establishing positive relationships as they are also charged with establishing partnerships. With current downsizing and dwindling resources, it is imperative that DoD facilities and the regulatory world work smarter together. Partnering is an excellent way to achieve this objective. The keys to establishing effective relationships include: 1) identifying key individuals within each regulatory agencies, 2) maintaining routine personal contacts within each regulatory agency, 3) monitoring contacts with the purpose of keeping a quality contact underscored by trust and sincere friendship, 4) providing a mission briefing to regulatory agencies as needed, and 5) offering assistance when possible. The handbook provides an overview of "how to" methods to achieve a successful partnering arrangement.

POLLUTION PREVENTION PROGRAM: P2 is a proactive and forward thinking management approach to Environmental Compliance. Industry has found that P2 initiatives make good business sense because they reduce the cost of doing business in terms of environmental compliance as well as liabilities. ACC's policy is to prevent pollution at the source whenever possible through source reduction, then through recycling or reuse, and then to use disposal only as a last resort. Each ACC installation is required to have a P2 Management Action Plan (MAP). The P2 MAP is the single reference used to manage the development and execution of an installation's P2 program. The "ACC Prototype Pollution Prevention Plan Version 2," dated January 1995, provides detailed guidance for developing an installation P2 MAP.

Key P2 Goals outlined in the handbook are: 1) hazardous waste reduction to 50% by December 1999, 2) ozone depleting substance reduction of 99% by December 1999, 3) reduction of solid waste by 50% by December 1997, and to 4) recycle 50% of waste by December 1997. Each goal is compared against a 1992 baseline. The solid waste and recycling goals are being reworked by DoD and may be adjusted to a diversion rate goal. ACC is adopting a solid waste goal along the following lines: ACC will, unless required by a local, state or federal mandate ensure the diversion rate for non-hazardous solid waste is greater than 40% by the end of FY 2005 while ensuring integrated non-hazardous solid waste management programs provide an economic benefit when compared with disposal using landfilling and incineration alone. The ACC goal will address regional variances such as climate, markets, demographics, and type of materials recycled.

The handbook also provides guidance in the following key P2 areas: 1) opportunity assessments, 2) technology needs, 3) hazardous waste minimization, 4) toxic release inventory, 5) pesticide management, 6) volatile air emissions, 7) ozone depleting substances, 8) municipal solid waste, 9) affirmative procurement, energy and water conservation and P2 team building. Hazmart implementation to provide cradle to grave tracking of hazardous materials and the move to P2 funding for compliance are key ingredients to a successful P2 Program.

The Civil Engineer organization was directed by AFI 32-7086 to lead the Hazardous Material Management Process (HMMP) team and report to the installation environmental protection committee. In March 1998 the HMMP issued a new hazardous material reduction goal and published it as part of the ACC environmental quality business plan. The Hazmart is part of the HMMP team and the base focal point for the management of Hazardous Materials (HM). It offers a single point of contact for base customers and provides centralized control for HM transactions.

Appendix K summarizes the revised P2 funding eligibility authorized by HQ USAF/ILEV. The push to a P2 mindset and P2 fund growth is supported by P2 investments in environmental compliance. For example, P2 managers should consider initiatives in the following areas: projects to reduce air compliance requirements and emissions like low NOX burners, low volatile organic compounds coating operations, alternative fuel vehicle purchases, projects to achieve and maintaining drinking water compliance and reduce the potential for contamination, and activities that reduce or eliminate environmental permits. These and other opportunities will mean many current requirements can be and should be funded by P2 dollars. The decision to move towards P2 as a method of environmental compliance has been made and will continue to permeate our planning.

SUMMARY: With the draw down of both manpower and dollar resources, installation and HQ level efforts to achieve and maintain environmental compliance will become more challenging. P2 initiatives and funding should become a preferred avenue of choice for all ACC environmental managers to meet compliance needs. While this is a challenging mandate, through creative and innovative thinking it will be possible to continue to deliver high quality environmental programs expected within ACC.

The Environmental Quality Handbook is a consolidated tool for installation managers to understand Command policies and guidance regarding environmental compliance. Although only covered in this paper in an abbreviated form, program managers can see where emphasis should be placed to meet regulatory compliance or Command strategies. Maintaining full compliance with all regulatory programs does not happen by chance. Through the dedicated efforts of many environmental professionals utilizing resources like the Command Environmental Quality Handbook, ACC installations can continue to maintain world class environmental programs.

REFERENCES:

1. ACC Environmental Quality Handbook, 5 Sep 1997

2. ACC Pollution Prevention Manager's Library, 5 Dec 96.

3. Environmental Compliance and Analysis Services, Contract Management and Administration Procedures, Jul 97.

4. Hazardous Waste Compliance Assessment, prepared by Oak Ridge National Laboratory for Air Combat Command, Jun 95.

5. Air Force Environmental Handbook for Contingency Operations, HQ USAF/ILEV and AFCESA/CEX, Aug 96.

OPTIMIZING ACTIVITY BASED COSTING (ABC)

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INTRODUCTION

Activity Based Costing is a method to identify the specific costs of providing products and services and assign them to the activities that cause those costs. For example, if a process generates 4 barrels of hazardous waste per week, the disposal costs for the waste would be charged to the generating process. However, the current practice in most cases is to simply lump all environmental compliance costs in an overhead account that is then applied equally to all cost centers within a company making it difficult to determine the actual cost of providing any given service. The reason a company would adopt an ABC system is to ensure that the cost burden of providing each product or service in a company is identified and charged specifically to the responsible cost center. This, in essence, forces each product or service to generate sufficient revenues to cover the costs they generate.

There is little question that industry has embraced the concept of Activity Based Costing (ABC) and literature shows benefit cost ratios of up to 100 times the initial start-up investment. However, these measurements are generally made after ABC is implemented. As a result, the analysis is based on total pre-ABC cost vs. total post-ABC cost. This implies that the only conclusion that can be drawn is whether or not ABC was economically beneficial when the real question should be whether or not the ABC application was optimized.

ABC Benefit/Cost Model

Optimizing ABC, as well as any other investment endeavor, means that the marginal benefit of using ABC is equal to the marginal cost. Hence, these two factors must be measured. On the benefit side, the advantage of implementing ABC is easy to define, the system provides accurate cost information, but difficult to measure – what is the dollar value of this information. Conversely, the three cost elements of implementing ABC, computer hardware/software, personnel training, and data entry/analysis, are relatively easy to estimate.

The benefit is available under the concept that if people are forced to pay for costs, they will do everything in their power to reduce those costs. The result is that it must be presumed that the personnel will be empowered with the authority to make changes to reduce costs. If this can be assumed, estimating the benefit can be relatively straightforward. If a company is a candidate for ABC, it follows that they are

currently rolling environmental costs into overhead (i.e., the waste generators do not pay for the environmental services they require). In a similar context Goddard (1995)[1] found that the elasticity of demand for waste management services was 0.20 (measured as a reduction in waste generated). This implies that each unit increase in price for the waste generator will result in a 20% reduction in waste generation. If it can be assumed that a waste generator who goes from paying none of the cost to paying all of the cost for environmental services will fall into the same category as a generator who saw a cost increase, the 20% savings predicted by Goddard should be applicable. This implies that every dollar charged back to the waste generator will create $.20 in benefits. These percentage savings were also supported by other data collected by Goddard[2]

This 20% savings establishes a minimum level to the benefit of ABC. However, to complete the picture, one must consider the effects of investing the savings. If the waste generator is given the capability of investing the savings realized from his or her efforts into pollution prevention projects, the net benefit can be increased. Ogden (1996)[3], Friend (1994)[4] and the U.S. Department of Energy (1995) [5] have documented an approximate payoff for pollution prevention investments of 3:1. Factoring this into the ABC benefit means that every $1.00 charged back to a cost center gives the generator $.20 to invest in pollution prevention. This equates to a pollution prevention savings of $.60 or a net savings for ABC of $.60 - $.20 invested = $.40; a 40% return on or every dollar charged back to a waste generator.

On the cost side, the three cost elements, computer hardware/software, personnel training, and data entry/analysis are more easily defined. Because most companies have an established computer system, the first element is generally limited to a software purchase. ABC software costs run from $7,000 to $11,000 depending upon whether it is for a single organization or if a network license is required and costs for training the ABC champion are included in this total. This study assumed that no additional hardware was needed and there would be an $11,000 total investment for software and training. To simplify the analysis, the life of the software was taken to be 1 year with the entire cost depreciated within that time. If the software were used longer than this, the cost per year would be less making the analysis conservative in that the costs would be lower. This one-year life was continued throughout the analysis

The final cost element, data entry/analysis, is a combination of two factors. First, the ABC champion who was trained by the software provider must set up the system.

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[1] Goddard, Haynes C., "The Benefits and Costs of Alternative Solid Waste Management Policies," Resource, Conservation, Recycling Journal: 183 (June 1995)
[2] ibid
[3] Ogden, Douglas H., "Booosting Prosperity: Reducing the Threat of Global Climate Changes Through Sustainable Energy Investments," 1996, WWW address: http://www.crest.org/efficiency/aceee/pubs/e963.html.
[4] Friend, Gill, "Light Bulbs, Trade Wars and Shareholder Suits," *The New Bottom Line*, 22 Feb 94, WWW Address: http://www.eco-ops.com/eco-ops/nbl/nb..3.3.html.
[5] U.S. Department of Energy, Office of Federal Energy Management Program, *Federal Energy Management: Billions Saved, Billions More to Come*, 1995, The Federal Energy Management Program, WWW Address: http://www.eren.doe.gov/femp/bsbmtc.html.

Depending upon the complexity of the system, this task has been estimated to take from 50 to 200 hours.[6] For this study, it was assumed that establishing the database would require 150 hours. Second, an allowance must be made for both the analysis and data entry; it takes time for the employee providing environmental services to enter the time and equipment charges into the ABC software database. It was assumed that this task would require no more than 10% of the total time spent on a given environmental service. Hence, if an employee spent an average of 10 hours/month manifesting hazardous waste, 1 hour would be allotted to entering the data and performing the ABC analysis.

To transform hours in to dollars, hourly costs had to be assigned to each environmental employee. The following enlisted, officer and general schedule employee pay groupings were developed:

Group	Pay Categories	Hourly Rate ($/hr)
A	E3 and E4	11.00
B	E5-E8, O1, O2, GS7-GS11	17.00
C	E9, O3, O4, GS12, GS13	24.00
D	O5, GS14, GS15	34.00

A survey of 3 Air Force bases showed most installation-level environmental employees to be in cost categories B or C. To predict the costs for this study, it was assumed that the ABC champion would be a category B employee and other employee's pay categories were computed according to the actual staffing for a given organization. Hence, the benefit can be estimated ($.40 for every dollar charged back), the software costs are known ($11,000), and the data entry/analysis/training costs can be estimated/computed from actual workers salaries.

Field Testing:

The two environmental management personnel, both category B, at Cheyenne Mountain AFB were asked to detail the time they spent on a variety of environmental tasks[7] for each customer on their installation. The ABC costs, as outlined above, were computed and compared to the potential benefits for all of the customers receiving their environmental services on a net present value basis. It was discovered that at Cheyenne Mountain, the benefits outweighed the potential ABC costs for all customers.

To investigate the sensitivity of the analysis, the expected benefit was lowered and the calculations repeated iteratively until the cost of the ABC system was greater than the expected benefit; this occurred at a benefit level of 26%. Similarly, the benefit was held constant at 40% and the estimated time required for data entry/analysis was

[6] Spinner, Paula C., Senior Analyst, Secretary of the Air Force, WWW Address: http://www.saffm.hq.af.mil/SAFFM/FMC/abc8.html

[7] Environmental task areas taken from Sullivan, F.P. Thomas, *Environmental Law Handbook, Thirteenth Edition*, Maryland: Government Institutes, Inc., 1995, p. 333.

varied until the expense of providing ABC analysis for one of the customers became greater than the benefit. This provided a percent return required (i.e., minimum benefit) vs. percent of labor required for data analysis relationship as shown in Figure 1.

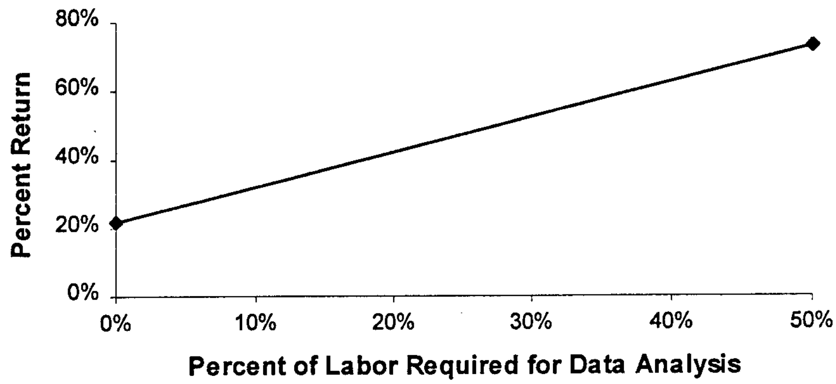

Figure 1. Sensitivity Analysis for ABC Optimization Techniques: Minimal Return vs. Percent Labor Needed to Charge Environmental Costs to All Customers.

This graph enables the analyst to investigate whether or not ABC would be financially beneficial under a variety of different circumstances. For example, if an analyst thought the benefit expected was in line at 40%, but that the percentage of time allotted for data entry and analysis was too low. The graph shows that for a 40% return the time spent on data analysis can be as high as 19% and ABC would still provide a positive net present value. Similarly, if the 10% of labor spent on data analysis was considered correct, the graph shows that the percent return could be as low as 31% and still provide a positive net present value.

A similar analysis was performed to determine the combinations of return and percent time for data analysis at which it became financially unattractive to track any of the activities at Cheyenne Mountain AFB. Figure 2 shows the results of this second analysis superimposed over the Figure 1 graph shown previously.

Again, interpreting this graph is relatively easy. The analyst considering implementing ABC first determines whether the 40% benefit and 10% costs appears high or low. Then the chart is used with the selected combination of expected percent return and percent labor. If the selected data pair is above the top line of the chart, charging all activities for environmental services will result in a positive net present value. Conversely, if the percent return/percent data pair is below the bottom line of the chart, ABC cannot return a positive net present value.

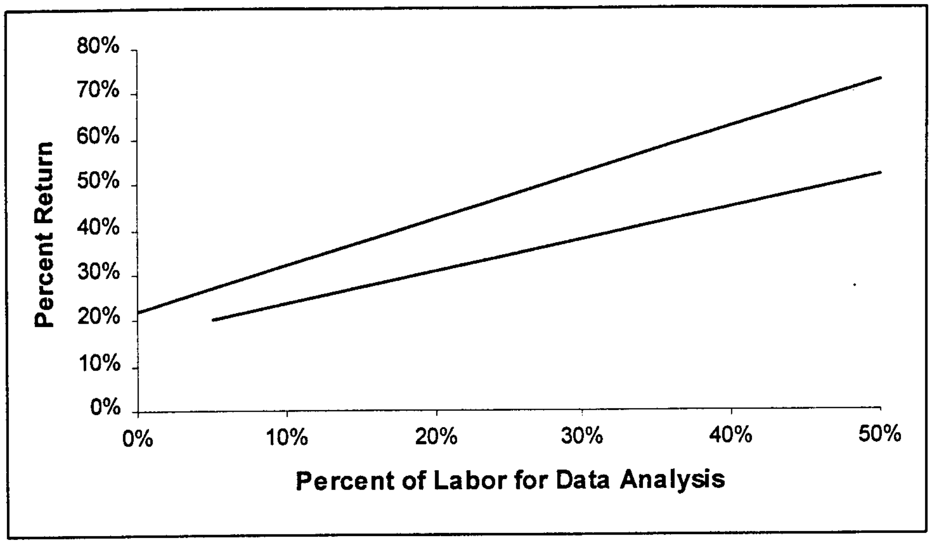

Figure 2. Sensitivity Analysis for ABC Optimization Techniques: Minimal Return/ Percent Labor Needed to Charge Environmental Costs to Any and All Customers.

The final possibility for Figure 2 is the data pair falling between the two lines. This indicates that only some of the activities should be charged for environmental services to ensure a positive net present value for each. To determine which activities to charge and which to exclude from ABC requires the net present value of ABC to be computed for each activity using the selected values for percent return and percent of labor. Any activity with a negative present value is then dropped and the analysis is repeated. The reason the analysis must be continued is because by dropping the activities with a negative present value, the costs for the software, hardware, and training must now be spread over fewer customers increasing their share of this expense. These calculations are continued until all of the activities show a positive net present value.

This analysis was completed for two other air force bases with environmental budgets nearly ten times larger than Cheyenne Mountain ($1,600,000 vs. $196,000). In addition, the software/training costs were spread over 1, 2 and 3 years.[8] In each case the analysis showed that all customers could be charged for environmental services.

On the surface, it would seem that the optimization model is of little use if in fact all organizations examined should charge all environmental costs to all customers. However, this is a function of how two of the variables were defined when the model was established; the environmental activities to track and what constituted a customer. First, the definition of an environmental activity had to be defined in that these functions performed by the environmental staff form the basis of how the environmental personnel

[8] Gutterman, Anthony J., "Development of Activity Based Costing (ABC) Optimization Tool for an Environmental Organization, Master's Thesis, Air Force Institute of Technology, AFIT/GEE/ENV/97D-08.

track their time. If the activities were too general or defined too broadly, it would have been difficult to establish a cost center. Conversely, if they had been defined too specifically, there would have been too many customers. This would have increased the cost of maintaining the database.

The second variable, the definition of a customer for the environmental organization, would determine the costs of administering the ABC system. More customers would mean more recordkeeping for the environmental personnel, more analysis time for the ABC champion, etc. For example, if the mission of the Air Force is to fly and fight, at one extreme all costs could be charged to the flying squadron as a single cost center. Unfortunately, this is very similar to lumping all costs into a single overhead account. As is the case with overhead, it makes little sense to charge the flying squadron because they are neither responsible for providing the services nor do they have they any control over the processes that generate the requirements for environmental services; they would have responsibility but no control. At the other extreme, customer selection can become too specific by taking it from a group to a flight to a section to a shop, etc. In this latter case, narrowing the definition would create a great deal of specificity for customers and costs, but the data would soon become too cumbersome to analyze or collect.

The value of the optimization model is apparent. If the analysis shows that few if any customers can be charged for environmental services, the definitions of customer as well as activity could be altered and the model run again. If the variables are selected correctly, using the optimization model can do many things for a company. First, it will ensure that only the customers who stand to gain more than they lose (e.g., the marginal benefits are equal to or outweigh the marginal costs) will be selected for ABC implementation. Second, it can be used to determine the overall benefit of using ABC if the net present values for each customer are simply added. Finally, it allows for post implementation investigation to see if the expected savings have been realized. If they have not, then the assumed values for return and data input/analysis can be revisited. If the expected savings have been exceeded, the new data can be input to the model. This could have the effect of expanding ABC to include the customers who had been excluded due to a negative net present value. This would have the net effect of further increasing benefits. The model can serve as a quick check as well as a basis for detailed analysis to ensure that only those specific activities that would benefit will be included in the ABC system.

Pollution Prevention Strategic Planning at
U.S. Army Military District of Washington

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ABSTRACT

The Department of Defense (DOD) and Department of the Army (DA) have directed that environmental compliance will be achieved and sustained through pollution prevention (P2). The benefit of this approach is clear for high-impact and high-cost industrial and training operations within the Army.

The U.S. Army Military District of Washington (MDW) is a unique and highly diversified Major Army Command (MACOM) that consists of seven installations assigned to five military communities. It lacks a concentration of heavy industrial operations and large-scale training operations typical of many other Army MACOMs; consequently, many of the typical P2 projects and initiatives undertaken at installations in other MACOMs are not applicable to MDW installations. However, MDW's installations are situated in environmentally sensitive areas with high public visibility. For these reasons, MDW developed a MACOM-wide pollution prevention program that includes environmental benefits along with economic value.

Our analysis indicates that the previous P2 program funding was not consistent with the intent to achieve compliance through P2. To move its P2 Program toward the directive of achieving and maintaining compliance through P2, MDW established six objectives for a new P2 Program in the MACOM. MDW then evaluated its existing systems, conducted a needs assessment of all of its installations, and prepared a P2 Strategic Plan that included an eight-step P2 Program. MDW's P2 Program funding strategy includes use of (1) the Army's Service-Based Costing model, the Implementation-Pollution Abatement and Prevention Analysis (I-PAPA); (2) an additional cost-benefit analysis developed by the MDW/Harding Lawson Associates (HLA) team; and (3) a decision matrix developed by the team to evaluate a project's indirect cost and non-economic benefits.

This P2 Strategic plan and its funding strategy allow both installations and MDW to promote candidate P2 projects using a consistent methodology of economic and non-economic factors. The funding strategy generates both an installation request and MACOM-wide request for P2 funding that provides consistency across that MACOM and optimizes the use of DA funds and resources for viable P2 projects.

INTRODUCTION

The U.S. Army Military District of Washington (MDW) is 1 of 15 Major Army Commands (MACOM), with headquarters at Fort Lesley J. McNair in Washington, D.C. MDW is a multifaceted MACOM whose responsibilities are focused primarily on the National Capital Region (NCR). The mission of the MDW is to:

- conduct security or disaster relief operations in the NCR
- provide base operations support for US Army and DoD organizations throughout the NCR
- conduct official ceremonies and public events on behalf of the US Government civilian and military leadership

Maintaining a cost-effective and efficient MACOM-wide environmental program is an important element in ensuring sustainable execution of MDW's mission. The Department of Defense (DOD) and the Department of the Army (DA) have directed that environmental compliance will be achieved through pollution prevention (P2) and that MACOMs and installations will prepare P2 Plans.

MDW is comprised of 7 installations assigned to 5 military communities. MDW is a unique and highly diversified MACOM that lacks a concentration of heavy industrial operations or large-scale operations typical of other DA MACOMs. Consequently, many of the typical P2 projects and initiatives undertaken at installations in other MACOMs are not applicable to MDW. However, MDW's installations are situated in environmentally sensitive areas with high public visibility. For these reasons, a cost-effective and efficient MACOM-wide P2 Program is essential.

MDW has prepared this P2 Strategic Plan to:

- define its P2 strategy;
- communicate policy, guidance, and information required by each installation within MDW to support its P2 Program; and
- ensure the MACOM-wide P2 Program is consistent across all installations, efficient, and cost-effective.

The Strategic Plan outlines the P2 Program MDW will implement to achieve environmental compliance.

OBJECTIVES

MDW has established six objectives regarding P2. These objectives were developed and are stated in the Strategic Plan for two primary reasons. First, it is imperative to the success of the Program that MDW's objectives are established and that any actions or initiatives undertaken by MDW or the installations only be taken to fulfill one or more of the objectives. Second, MDW must communicate its MACOM-wide objectives to every installation to ensure that all installations recognize and understand the MACOM-level objectives and priorities. It is only with this understanding that MDW will ensure its P2 objectives are met.

Military District of Washington MACOM-wide P2 Program Objectives	
1.	**Support the Military Mission** Metric: No interruption of the military mission due to environmental issues.
2.	**Achieve the DOD P2 Measures of Merit (MOMs)** Metric: Strive to achieve the MOMs by the Compliance Date.
3.	**Reduce Costs for Treatment, Disposal, and Compliance Through P2** Metric: Yearly reduction in treatment, disposal, and compliance costs, normalized against installation population (e.g., gallons of water used/ person), for sustained operations.
4.	**Use P2 to Maintain Environmental Compliance** Metric: No environmental compliance violations.
5.	**Maintain DA-Compliant P2 Plans** Metric: No ECAS audit findings due to non-compliant P2 Plans.
6.	**Optimize the Use of P2 Funding in the MACOM** Metric: Demonstrated cost-effective results from P2 fund expenditures.

Installations will develop and communicate additional installation-specific P2 objectives to MDW. These additional installation-specific objectives should reflect the MACOM-wide P2 Program objectives, or, due to the unique and diverse nature of MDW, address site-specific issues.

APPROACH

Through the development and distribution of this Strategic Plan, every installation in the MACOM will share a common understanding of the definition of P2 and MDW's requirements for P2 project identification and economic evaluation. Installations will request funding for P2 projects that meet MDW's definition of P2 and support the MACOM-wide P2 objectives stated in the Strategic Plan. MDW will utilize the funding strategy described in the Strategic Plan to generate a MACOM-wide request for P2 funding that optimizes the use of Department of the Army (DA) funds and resources.

Management of MDW's P2 Program in this manner will generate uniform and consistent P2 project identification and evaluation by its installations, resulting in effective and beneficial distribution of P2 funding received from DA. Implementation of MDW's P2 Strategic Plan will accelerate MDW's ability to meet DOD's directive of "compliance through pollution prevention" and attain the MOMs, and will, over time, reduce costs for treatment, disposal, and compliance.

POLLUTION PREVENTION PROGRAM

Pollution prevention is the use of materials, processes, or practices that *reduce* or *eliminate* the creation of pollutants or wastes *at the source* (i.e., source reduction). It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use. Pollution prevention includes methods and techniques that reduce the generation of toxic chemicals, hazardous waste, solid waste, or wastewater. Pollution prevention is DA's and MDW's preferred mechanism for achieving environmental compliance and is an integral component of the MDW's environmental management strategy.

MDW will consider potential projects for funding in its P2 Program that cost-effectively:

- support achievement of DOD MOMs goals;
- support MACOM-wide P2 objectives;
- support installation-specific P2 objectives; and
- reduce water or energy use.

MDW will only consider installation projects under the P2 Pillar that have been developed in accordance with MDW objectives. Installation's projects that do not achieve P2 objectives may be submitted for funding under other environmental pillars such as Compliance, Conservation, or Restoration, as appropriate. Potential projects that reduce the cost of **maintaining** compliance will be considered as P2 projects. For example, a closed-cycle vehicle washer will maintain compliance and ultimately avoid the compliance issues associated with traditional wash racks.

IMPLEMENTATION AND FUNDING STRATEGY

MDW has developed its Strategic Plan to meet the objectives for its MACOM-wide P2 Program. The 8 steps necessary for an effective P2 program at MDW are illustrated in Figure 1 and explained briefly in the text below.

Development of the Strategic Plan is the first component of the P2 Program (Step 1). The Draft Strategic Plan was then submitted to each MDW installation and the MDW staff for review, and the Final Strategic Plan was issued to each installation following incorporation of responses to comments (Step 2). MDW then modified its MACOM-level P2 Plan to incorporate existing DA guidance and aspects of the Strategic Plan: together these documents, in conjunction with the installation P2 plans, form the entire basis of MDW's P2 Program (Step 3). MDW will assist each installation in updating its P2 Plan to conform with the intent of DA guidance, and in developing a schedule for P2 Plan updates and P2 Opportunity Assessments to coincide with Environmental Compliance Assessment System audits (Step 4). Installations will use existing DOD and DA documents as guidance in identifying needs for environmental projects (Step 5).

Key to the P2 Program is the funding strategy, which is comprised of steps 6 and 7 (Figure 1). The most difficult issue MDW faces in implementing its P2 Program is to develop a system to allow its best P2 projects to compete for DA funding with projects from other MACOMs that have industrial operations. MDW does not have large industrial operations and, therefore, does not generate large, costly hazardous and toxic waste streams.

MDW projects are worthy of funding when considering aspects that are not readily put into economic pay-back terms. Many MDW installation are located near environmentally sensitive areas and waterways (i.e., Chesapeake Bay, Potomac River, Anacostia River) with high public visibility. To address these issues, MDW has developed a 3-stage project evaluation process that requires installations to:

1. Execute the Service-Based Costing model (I-PAPA) developed by the Concepts Analysis Agency;
2. Develop dollar-based cost/benefit analyses (C/B) using the worksheet developed by the MDW/HLA team; and,
3. Use a Decision Matrix model developed by the MDW/HLA team which incorporates non-economic factors for each candidate project.

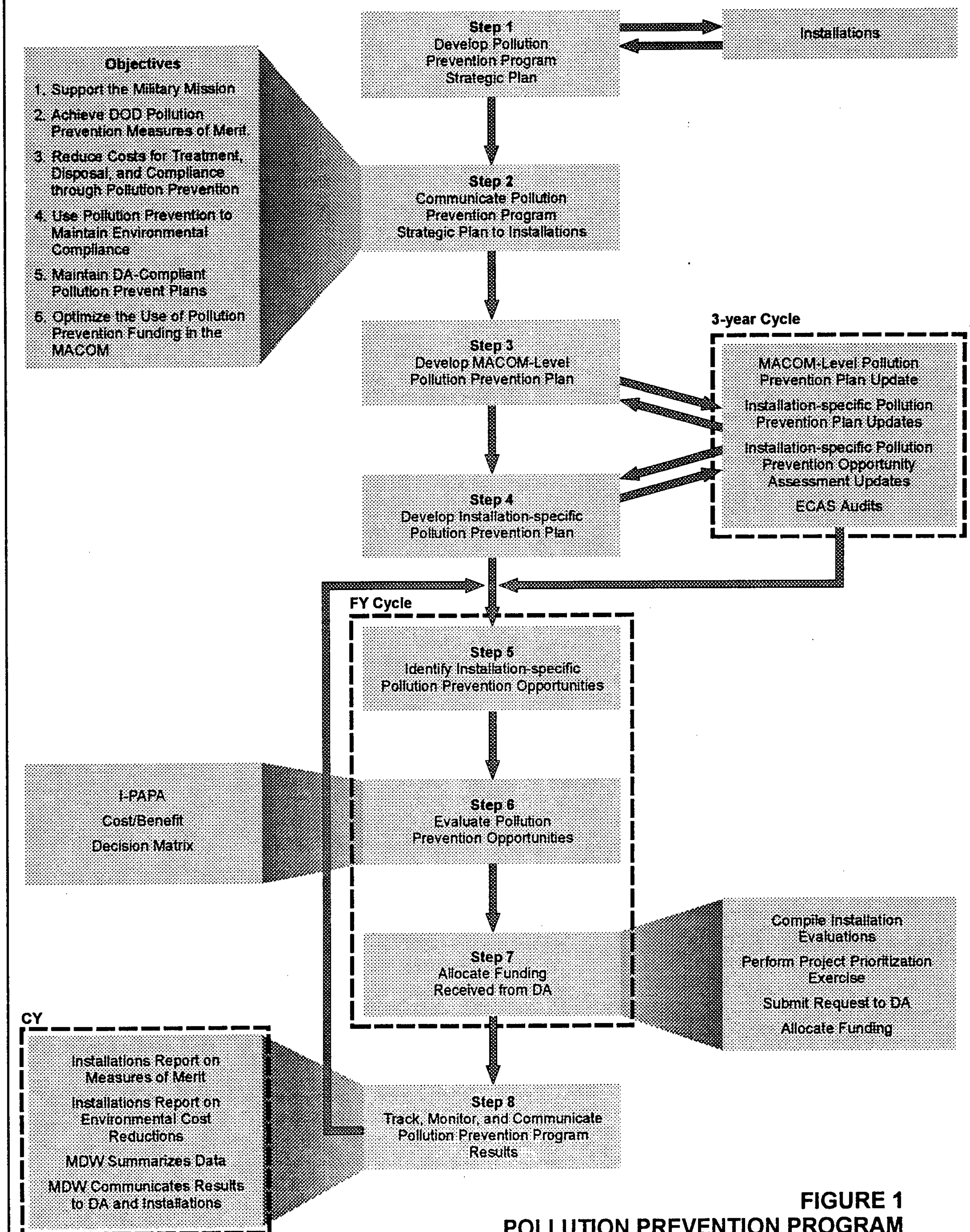

FIGURE 1
POLLUTION PREVENTION PROGRAM
MILITARY DISTRICT OF WASHINGTON

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Once ranked at the installation level, installation environmental coordinators (ECs) submit the ranked P2 projects to MDW for evaluation and funding requests. This includes incorporating I-PAPA data into the Environmental Project Requirements (EPR) Report. MDW will weigh the results of all 3 project evaluations in setting priorities for funding. This method of project evaluation will ensure that MDW requests funding for cost-effective projects that enhance environmental protection and support - or don't impede - the MDW mission (Step 6).

Candidate P2 projects must contain some combination of the following: attractive pay-back results from the I-PAPA model (i.e., <5 year return on investment), significant environmental cost reduction benefits, or other environmental benefits to be included in MDW's request for funding to DA. These environmental benefits may be difficult to quantify, such as riparian buffers to protect Chesapeake Bay, or habitat protection for eagles. "Must fund" P2 projects must lead to cost-effective removal or reduction of the need for compliance by replacing procedures, practices, or equipment related to control or treatment approaches to compliance.

MDW will allocate funding received from DA for all environmental projects, including P2 projects, based upon the priorities established during project evaluation (Step 7). MDW's P2 Program has a structured tracking, monitoring, and communication element. Certain installations may not be able to cost-effectively achieve specific goals in MDW's Program due to site-specific constraints. MACOM-wide objectives will be emphasized to create a sense of teamwork throughout MDW and toenhance data validity at the MACOM level (Step 8).

SUMMARY/CONCLUSIONS

Our analysis indicates that the previous P2 program funding was not consistent with the intent to achieve compliance through P2. To move its P2 Program toward the directive of achieving and maintaining compliance through P2, MDW established six objectives for a new P2 Program in the MACOM. MDW then evaluated its existing systems, conducted a needs assessment of all of its installations, and prepared a P2 Strategic Plan that included an eight-step P2 Program. Key to MDW's Strategic Plan is a funding strategy that evaluates projects using tools provided by MDW: the Army's I-PAPA; a cost/benefit analysis developed by the MDW/HLA team; and a decision matrix model developed by the MDW/HLA team which incorporates non-economic environmental benefits. This P2 Strategic plan and its funding strategy allow both installations and MDW to promote candidate P2 projects using a consistent methodology of economic and non-economic factors. Application of the "P2 tools" by installations and the MACOM will streamline the P2 project ranking process and allow for optimization of limited Army funding.

ACKNOWLEDGMENTS

We would like to thank Colonel York, U.S. Army (Retired), and the ECs of all MDW installations for their support of this effort.

Session XXI
Hazardous Material Control

Session Chairpersons:

Mr. Randy Carar, Army Environmental Center
Mr. Skip Sowards, UNITEC

SUCCESS!
The Fielding and Operation of a Hazardous Material & Hazardous Waste Software Program
AF-EMIS

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The Objective and Scope:

The objective of the presentation will be to provide the listener with a comprehensive understanding of both the successful fielding efforts, and subsequent successful operation of the Air Force-Environmental Management Information System (AF-EMIS), now deployed to over 150 Air Force and Air National Guard installations. It will begin with the background story to understand how and why this system was selected for the Air Force, what steps were taken to accomplish the fielding, what the ongoing support for the system consists of, what the future has in store for AF-EMIS, and the lessons learned from the fielding and operational support.

The Steps:

The first step in this effort was selecting a system compatible with Air Force business practices. The system also had to be acceptable and comparable, both in operational style and format to what the Air Force user was accustomed. At the conclusion of the 1994 Air Force Pollution Prevention Conference, a consensus was reached regarding the "in place" hazardous material tracking system – it did not meet the needs of the Air Force. In September 1994, the Air Staff directed a "tiger team" determine if another system might meet the needs of the Air Force better. The tiger team met several times over the next couple of months, and reviewed a number of candidate systems. In addition to the review of their system requirements, the team traveled and saw the systems in operation. All the systems demonstrated some excellent features, and each had some shortcomings. The task was to calculate which system had the most positives, and the least negatives. Each major command, including the Air Force reserves had one vote. HQ AFCEE was an observer in this process, but was not a voting member. Upon the conclusion of the vote count, the team recommended the Kelly AFB Environmental Management Information System (EMIS) to Air Staff. HQ USAF/CEV approved the recommendation in a policy letter dated 25 Oct 94. Approval from the Defense Environmental Security Corporate Information Management office was not received until 10 Jan 95, and the decision was included in the DESCIM IDP, 11 April 1995. With this approval HQ USAF/CEV directed the HQ Air Force Center for Environmental Management (HQ AFCEE) to proceed with the activation of EMIS. The Air Force issued a recommendation concurrence document signed by HQ USAF/CEV/LGM/LGS, SAF/AQX and HQ AFMOA/SGP on 17 January 95. This concurrence letter clearly demonstrated the overall support for the selection of this software application.

The second step was to transform the Kelly AFB EMIS from a system designed to support the needs of a single installation into one with the ability to meet the needs of bases from every Air Force command, and 78 Air National Guard installations. The resources for this effort came from, and continue to come from HQ USAF/ILEVQ. The execution and program management resources are located within HQ AFCEE. The first year effort of approximately $1.5M resulted in the award of a contract to a software corporation located in San Antonio, and a training contract to a nationally known environmental firm. Over the next

two years, personnel from these two contractors, approximately 20 individuals, and 2-4 government personnel were totally dedicated to the transformation of the Kelly AFB EMIS to Air Force-EMIS. The initial contracts were awarded in the summer of 1995. The first fielding of AF-EMIS was to Holloman AFB in January 1996. There were many hurdles to overcome, and many remained.

The Kelly AFB EMIS was in day-to-day operation at the large Kelly AFB industrial complex when it was elected to become the system of choice for the US Air Force. With the developers close at hand, it was a proven commodity for the base, but now it would graduate from the security of the base and go it alone. To do this, it needed some assistance. The assistance came in many forms. Some of those were re-styling to be more "Windows" compliant, on-line help, extensive testing, user and system administrator guides, tutorials, connection of widows and orphans, curriculum development, and data conversion programs.

Not only were we faced with the software challenges, we were faced with the marketing of the AF-EMIS to the Air Force, and the unusual organizational structure of where it was to be placed – the Hazardous Material Pharmacy. In 1995 there was only a very loose organizational structure to the HMP based upon the Hazardous Material Pharmacy Implementation Plan, 31 May 95. The Plan, also known as the Organizational Change Package, indicated the logistics supply community would be the lead, in spite of the evidence the environmental organization was much more interested in the outcome of the process. To get buy-in from the entire Air Force community a steering group was formed with representatives from all commands and all functions effected by hazardous material management. The steering group met, a plan was agreed to, and the steering group did not meet again for a year. They did not meet again for a year, because there was no need to meet. HQ AFCEE had enough direction to take them a year to complete….and then some.

The third step was making AF-EMIS operational for every user. Making a system operational is much more than delivering a piece of software. This was especially true of AF-EMIS, since initially there was no mandatory direction to use it. The direction to HQ AFCEE was to make AF-EMIS available to every Air Force and Air National Guard installation. This objective was met by January 97. The tasking was not to ensure its full operation at every base, nor to control whether the base used all the modules. The Air Staff looked towards the bases and their major commands to take up the tool and use to its maximum potential.

To demonstrate its capabilities and encourage use, HQ AFCEE devised a series of training experiences to better prepare the hazardous material pharmacy personnel to use it. A series of system administrator training classes were conducted in regional locations around the world. A total of 26 sessions were held over a one-year time span. In addition, US Air Force School of Aerospace Medicine stepped up and joined in partnership with HQ AFCEE to offer the AF-EMIS class. Approximately six classes have been held every year since 1996, and all have been at capacity. The AF-EMIS newsletter was first published in 1996 and over 600 pages of on-line help were completed in time for AF-EMIS version 2.0.

The current version of AF-EMIS is 5.0. The next version 6.0 is expected to be released at the end of 1998. This version will include archiving, and a greatly expanded and improved Chemical Abstract Table, and environmental reporting feature, specifically Emergency Planning and Community Right-to-Know, Section 313. Features activated or enhanced since AF-wide deployment began include:

- 2.0 -- bar-coding
- 3.0 -- waste module
- 4.0 -- QSL and HMIS interface
- 5.0 -- standard base supply interface.

The Results:

AF-EMIS is a success both to the user and to the pocketbook. AF-EMIS is a very economical system. Hardware requirements are closely identified with the Air Force standards for personal computers, and the software is government–owned. AF-EMIS, used in conjunction with the hazardous material pharmacy concept, is responsible for saving the Air Force millions of dollars. AF-EMIS is also supplying environmental information quicker, and easier than any other system.

The Continuing Developments:

To maximize performance, and to comply with changes in Air Force direction as well as other imposed mandates, AF-EMIS is under continual development. The AF-EMIS configuration control board meets regularly and encourages user participation. Every change request, without regard to its magnitude is assigned a change request number. The requester is provider the date and time of the configuration control board meeting, so a call may be made during the meeting to advocate for the proposed change. This is done through a "meet me" conference call. The meeting handouts are posted on the HQ AFCEE web site in advance of the meeting.

AF-EMIS is becoming a standard system, easing the day-to-day business practices for those managing hazardous materials. Judging by the new change requests being received, upcoming improvements will focus on interfaces with other systems, and improved reporting.

A Study in Performance Based Contracting

of

Cradle-to-Grave Hazardous Material Management

Presented by Captain Linda Ray
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INTRODUCTION
An Air Force Base is undertaking an initiative to acquire a commercial contractor to manage and operate the hazardous material (HAZMAT) and hazardous waste (HAZWASTE) functions, from cradle-to-grave. These functions include the Hazardous Material Pharmacy (HAZMART), the 90-day Central Accumulation Site, Recoverable Petroleum Products Accumulation Point, and the Environmental Management Information System (EMIS). None of these areas are core Air Force competencies, nor are they related to war fighting skills. Competitive sourcing these functions will allow the Air Force Base to focus military personnel and resources on core Air Force missions consistent with Air Force Policy Directive 38-6, Outsourcing and Privatization.

OBJECTIVE
The objective of this initiative is to consolidate separate HAZMART and HAZWASTE facilities and functions performing related activities and capitalizing on private industry's strengths, experience, and innovation to provide efficient and effective HAZMAT and HAZWASTE management and operations on the military installation.

PERFORMANCE REQUIREMENTS
The contractor must:
(a) Process and approve new requisitions of hazardous material; receive, inspect, store, issue, and distribute HAZMAT;
(b) perform the data entry and employ the EMIS hardware and software to provide data management, reporting and training;
(c) manage the turn-in of base hazardous waste by working with Defense Reutilization and Marketing Office waste disposal contractors;
(d) prepare manifests and develop and track waste stream profiles;
(e) monitor the handling, storage, and turn-in processes, and finally,
(f) coordinate the disposition of recoverable and unusable products.

THEORY
This initiative is in response to the Air Force competitive sourcing and privatization goal to do business better, cheaper, and faster--thus freeing up funds for force modernization. The operating principle underlying this initiative is that it is more economical for private industry to perform the Base HAZMAT and HAZWASTE functions than currently performed in-house.

BACKGROUND

This project began as a modest idea to outsource the HAZMART function controlled by the base's Supply Squadron. The idea then evolved to integrate similar activities to create a synergism with greater economies. A multi-functional team was created to study the feasibility of improving the hazardous material management process while reducing the cost of operations.

The multi-functional team members are Base Supply, Environmental Management, Bio-environmental, Contracting, and Manpower. This cradle-to-grave initiative also involves several units not under the control of the installation support Wing such as Defense Reutilization Management Office and contracted waste transportation. The greatest challenge facing the team is to shift the focus of each function from their individual benefits or losses onto the value and capability of the group. Each function is attempting to protect their own investment in the existing HAZMAT process rather than agree upon the criteria that would benefit the Wing or the Air Force to the maximum.

Overcoming each organization's resistance to obtain a plan most beneficial to the Air Force is proving to be an arduous process. The idea to consolidate this particular process was not dictated by command or air force direction; therefore, our approach to success is not the usual way of doing business. Rather than following higher guidance, each function's leadership needed persuading that the Base could achieve greater efficiency and cost savings when operating together rather than as independent entities.

BENEFITS

The Base envisions numerous benefits resulting from this initiative such as establishment of a single point of expertise for HAZMAT and HAZWASTE issues, savings through economies of scale and optimal inventory control, and overall lower costs of operations. The acquisition strategy employed to achieve these benefits is the award of a performance-based contract to a single qualified contractor using streamlined best-value contracting procedures. The contractor will use government-furnished facilities in the performance of the contract. This performance-based fixed price contract will shift risk management to the contractor by structuring the acquisition around the purpose of the work to be performed, not the manner in which it is performed. This will give the contractor the freedom to determine how to meet the government's performance objectives and achieve the appropriate performance quality levels. This approach is less costly to the government by providing the contractor the greatest opportunity to provide a quality service at a reasonable price. In addition, the contract will contain an award fee incentive tied to the contractor's effectiveness and success in reducing hazardous material and waste quantities.

CONCLUSION

The vision is to achieve a lower cost, streamlined, and effective HAZMAT and HAZWASTE process on the Air Force Base by contracting for the most efficient management of the four non-military essential functions proposed for competitive sourcing. This concept is aligned with MAJCOM'S FY 99 direction to accomplish the mission in a "less expensive way" without sacrificing effectiveness. It is believed the revolutionary cradle-to-grave management initiative is the future of DoD hazardous material and waste tracking, handling, storing and disposal.

H

SMS: FULL "CRADLE TO GRAVE" IMPLEMENTATION AT SPAWAR SYSTEMS CENTER – SAN DIEGO

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Background

The Hazardous Substance Management System (HSMS) is an automated system for "cradle to grave" tracking and managing of hazardous material (HM) and hazardous waste (HW). It was created as a tool to implement the Consolidated Hazardous Material Reutilization and Inventory Management Program (CHRIMP). CHRIMP is a philosophy that establishes an environment for controlling, tracking and reducing the variety and quantity of HM in use at military facilities. In May 1995, the Chief of Naval Operations (CNO) mandated Navy-wide implementation of CHRIMP and directed Navy-wide implementation of HSMS at shore facilities.

HSMS evolved from the Portsmouth Naval Shipyard Hazardous Material Control and Management (HMC&M) System. HMC&M was selected as the Department of Defense migration system for hazardous material. Defense Environmental Security Corporate Information Management (DESCIM) selected HMC&M because it was an integrated system which supported pollution prevention, EPCRA and environmental reporting requirements by tracking HM through its lifecycle.

Implementation of HSMS

The Space and Naval Warfare Systems Center, San Diego (SSC-SD) is a research and development facility whose mission spans a variety of technologies. SSC-SD became involved in HSMS prior to the implementation of the San Diego region. In 1995, an HSMS Implementation Team was organized with members from the Safety and Environmental Office, Supply and all technical departments at SSC-SD that use HM. In April 1997, SSC-SD became an HSMS beta test site and was the first facility in the San Diego region to use HSMS.

One of the basic decisions required before implementation could begin was selection of the method for issue of HM. At some facilities, users of HSMS utilize the "Tool Crib Concept." Using this method, any HM issued during the work shift is returned to the central HM storage area at the end of the shift. In a research and development environment such as SSC-SD, this method would not work. SSC-SD decided to use a method called the "Library Concept." It is so named because it functions in much the same way as a library does. It is similar to the Air Force

"Pharmacy Concept." When someone needs HM, they come to the HM Minimization Center (HMC) to "check out" the item. This HM is reserved in their name and is theirs to keep as long as they need it. When they are finished with the HM, whether it is at the end of the day or next year, they return it to the HMC. Care is taken to issue only the amount of HM that is needed for the job in reasonably-sized containers. For instance, if someone will use 30 gallons of a solvent during a one-year project, the unit of issue may be one gallon at a time. The storage of the remaining HM is handled by the HMC.

Another decision to be made was how many codes (divisions or branches) to implement in the beginning. SSC-SD decided to introduce only three codes into HSMS for the initial implementation. These three codes were representative of the variety of processes at SSC-SD ranging from research to industrial. One code in the first group implemented into HSMS was the Test Engineering and Restoration Division. This group consists of about 150 people including both civilian and contractor personnel. The types of operations performed in this division are not as oriented to research and development as some other divisions at SSC-SD. These operations include electronic equipment repair, refurbishment and testing, abrasive blasting using glass beads, metal surface preparation with phosphoric and chromic acid solutions, painting, and general cleaning.

The start-up process involved establishing administrative and reference module data bases as well as instituting process algorithms for all operations that use HM. With the assistance of John J. McMullen and Associates (JJMA), the Naval Supply Systems Center contractor supporting HSMS, the HM in the initial codes was inventoried and barcoded. Once JJMA completed these tasks for the Test Engineering and Restoration Division, issuance of HM began using the "Library Concept."

Procedure for Disposition of Hazardous Material as Waste

When HM is returned to the HMC, a determination is made identifying the item as reusable or as waste. When a reusable HM is returned, it is entered back into the inventory of the HMC by a "returned" disposition. For all HM which has become HW (including any unusable, spent or contaminated HM), the proper "disposed" disposition is performed.

Prior to disposing of an HM as an HW in the HSMS Materials Module, links need to be established between the HM, the site-specific process for which it is used, and the waste stream for the generated HW. A guidance document for this was developed in-house. This document (titled "HSMS Waste Module Procedures") makes the process of linking much simpler and ensures that when a HW is created from an HM disposition in the Materials Module, errors which would result from incorrect or incomplete links do not interrupt the disposition process.

In the "HSMS Waste Module Procedures", the first step in disposing of an HM as an HW is to obtain information from the barcode attached to the HM. A worksheet was created to ensure that the necessary information is retained for future use. The key pieces of information recorded on the worksheet are the Specific Task ID Number, the person the HM was issued to, the Serial

Number of the container, the name of the item, the MSDS number, the NSN, the location or shop to which it was issued, and the percentage of the HM issued which is now being disposed as HW. The MSDS Number is then used to locate the chemical constituent information for the item. The CAS number for at least one of the chemical constituents is written down on the worksheet. Next, an HW container is created in HSMS. This is accomplished through the Waste Module by clicking on "Container Inventory", performing an "Insert", and entering the relevant information (container ID, type of container, size of container, unit/measure, and location of the container).

A waste stream must be developed to describe the waste. The two-character Naval Facilities Engineering Service Center (NFESC) waste code is used to designate the Waste Stream Category Code. When the waste stream constituent information window opens, at least one of the CAS numbers for the HM is entered to provide a link between the HM and the waste stream. Next, the Waste Profile is created. Every waste stream that relates to the specific waste profile is entered. Additionally, the waste profile constituents must be inserted. At least one of the CAS numbers from each waste stream must be entered. Each time a new waste stream is created, the appropriate waste profile along with its constituent information must be updated. To close the loop, the Site Specific Process is accessed in the Pollution Module. After clicking on the Waste button for that specific process, the proper waste stream is selected. This links the waste stream to the site-specific process.

Finally, after all the necessary information and links are established, the disposition for the HM can be done in the Materials Module by selecting "Transactions" and then clicking on "Input Disposition of Materials." If there is any amount of the HM going to disposal, a window will open that requires entry of the waste stream and HW container number, both of which were established in the linking procedure mentioned previously.

Pilot Transfer of Hazardous Waste

At SSC-SD, all HW generated is accumulated using either satellite accumulation or less-than-90-day accumulation. SSC-SD does not have a permitted treatment, storage or disposal facility onsite. Most HW from SSC-SD is transferred to the Navy Public Works Center San Diego (PWC-SD). At the SSC-SD Old Town Campus, where the Test Engineering and Restoration Division is located, all HW must be transferred to PWC-SD or a contractor via an HW manifest. Recognizing that our HSMS HW disposal procedures would need to mesh with that of PWC-SD and in order to facilitate complete integration of HSMS from cradle to grave, SSC-SD advocated the formation of an HSMS HW Working Group for the Point Loma Naval Complex and the Old Town Campus. Group members included SSC-SD, PWC-SD and Naval Submarine Base San Diego which is also part of the Point Loma Naval Complex. After several meetings discussing integration, a pilot transfer of HW from SSC-SD to PWC-SD occurred to test the recommended changes.

The key issue to be addressed before the pilot transfer could occur was the necessary paperwork. PWC-SD requires their customers to provide a standardized HW Profile Sheet for each waste stream and a HW Turn-In Form that lists the waste streams along with information on the waste

stream source and form. A simplified version of each of these forms, hereafter referred to as the HSMS Profile Sheet and the HSMS Turn-In Form, was produced using IQ (Intelligent Query) for Windows. Each HSMS Profile Sheet identifies the waste profile and waste stream name for a specific HW container. Also printed are the container size and the weight of actual HW in the container calculated by HSMS. The final information on the HSMS Profile Sheet is a list of every chemical found in the container showing the chemical name, CAS number and the percentage of each chemical in the container. In calculating the weight and percentage, HSMS only takes into account the constituents of the HM transferred into the HW container and does not include other components of the final weight as it will appear on the manifest (such as the weight of the container, debris, etc.). The HSMS Turn-In Form lists the HSMS Container ID and the HW category with blank spaces beside each container so that, at the time of waste pickup, notations can be made for the total weight and whether the waste was bulk or non-bulk. At the bottom of the form are blanks for the activity representative and PWC-SD representative to sign and date.

To schedule the pilot transfer, SSC-SD faxed to PWC-SD the HSMS Profile Sheets for each HW container and the HSMS Turn-In Form. PWC-SD used the information from these forms to generate a HW manifest in advance. PWC-SD performs all manifest functions for activities in the San Diego region. The only spaces on the manifest that could not be completed in advance were the weights of the wastes and the signatures of the generator and transporter. Additionally, PWC-SD utilized the information from the forms to complete Land Disposal Restriction (LDR) forms and Department of Transportation (DOT) HW labels for transport. SSC-SD uses a HW label that is appropriate for use onsite but is not compliant for highway transport.

When the pilot transfer occurred, the PWC-SD representative weighed each container, noted those weights on the HSMS Turn-In Form and wrote bulk or non-bulk for each container (which determines the disposal cost rate). The Turn-In Form was completed by writing the manifest number on the form and having the activity representative and PWC-SD representative sign and date the form. The manifest was then completed by entering the waste weights and appropriate signatures. The DOT HW labels generated in advance were then affixed to each HW container.

In the past, the total time that PWC-SD needed to spend onsite to complete a HW pickup was around three hours. The reason for this lengthy time period was that the PWC-SD representative needed to do most of the work at the pickup site. After first perusing all the MSDSs for each waste in order to classify the wastes properly on the manifest, the representative would then complete the HW manifest and LDR forms, as well as the DOT HW labels for each HW container. By receiving the HW Profile Sheets and the HW Turn-In Form in advance, PWC-SD can do most of the work before their representative arrives onsite. The descriptive HSMS Profile Sheet makes it unnecessary for the generator to provide to PWC-SD a large stack of MSDSs. Almost all of the paperwork and labels can be written before leaving for the pickup. The PWC-SD representative was onsite at SSC-SD for only 25 minutes during the pilot transfer.

Conclusions

As a beta test site, SSC-SD has successfully implemented HSMS to track HM and HW from cradle to grave. The method of HM issue chosen by SSC-SD is the "Library Concept" which allows personnel to "check out" a HM for an indefinite period of time, as long as the volume of HM requested is appropriate. Through cooperation with PWC-SD, SSC-SD has effectively demonstrated the smooth transition of hazardous waste from a generating activity to an off-site treatment, storage and disposal facility by conducting a pilot transfer of HW. Both parties were satisfied with the paperwork utilized and the decrease in effort required to accomplish the pilot HW transfer. SSC-SD has continued to integrate more codes into HSMS. Transfers of HSMS HW to PWC-SD are now occurring regularly and have become standard procedure.

MULTI-PHASED APPROACH TO LIFECYCLE MANAGEMENT OF HAZARDOUS MATERIALS (#175)

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INTRODUCTION

Fort Lewis Military Reservation is an 86,176 acre Army installation located 35 miles south of Seattle and 7 miles northeast of Olympia. Various military and non-military organizations at Fort Lewis perform services and functions that require the use of hazardous substances and generate hazardous waste. These activities are vital to the field readiness of military troops and support the day-to-day functions of Fort Lewis as a community. Services include the maintenance of over 4,500 Fort Lewis buildings and infrastructure such as roads and utilities, operation and maintenance of over 3,000 vehicles and nearly 1,500 pieces of equipment including aircraft, weapons systems, power generators, and communications equipment. A major hospital, several medical and dental clinics, printing and graphics facilities, materials storage warehouses and crafts shops also operate on Fort Lewis.

Fort Lewis, the largest employer in Pierce County, has a combined military, civilian and retiree payroll of almost $1 billion. Fort Lewis' force structure includes I Corps Headquarters, which commands all Forces Command units at Fort Lewis. I Corps Headquarters conducts planning and also acts as a liaison with other active and reserve component units in the continental United States and active duty units located around the Pacific Rim and in Hawaii. Fort Lewis directly supports the Yakima Training Center and six Base Realignment and Closure installations in Washington and California. The installation also serves occasional users from other U.S. armed services and units from allied nations.

PROGRAM OVERVIEW

Tracking hazardous material procurement, storage, usage, and waste generation is one of the greatest challenges facing Fort Lewis. Understanding the lifecycle of a material and its movement through storage, use and waste generation is difficult. Overlapping management responsibilities and sometimes-conflicting guidance between logistics, safety, preventive medicine and environmental regulations presents interesting challenges. To meet the challenge, various business practices have been implemented over the last seven years to better manage hazardous materials.

Fort Lewis developed a multi-phased approach to achieve proactive management of hazardous materials throughout their lifecycle. We targeted programs and projects that placed the installation in a better compliance status. In 1991, Fort Lewis identified better management of hazardous waste as the top priority, and also implemented a pollution prevention program. Between 1992-1995, the installation developed various tools to help forecast usage of hazardous materials and waste generation. Documentation on processes and chemical usage was then developed. The post established hazardous material inventories and developed a database to track storage locations. From 1994-1995, Fort Lewis completed a study on centralizing hazardous material procurement. In 1996, the post received approval to establish a process action team to

implement the hazardous material control center (HMCC). In March 1998, the HMCC opened supporting all hazardous material users on Fort Lewis. The Hazardous Substance Management System will be in limited operation in August 1998.

TECHNIQUES AND INNOVATIONS

In 1991, Fort Lewis established and implemented a new concept for hazardous waste management: the One-Stop Hazardous Waste Management Program. Under this program, the hazardous waste management process is simplified for the units and installation activities.

Prior to the implementation of the One-Stop Program, soldiers were responsible for disposing of hazardous waste in accordance with the local, state and federal regulations. Under the old system, the soldiers were guided through a regulatory and paperwork maze for hazardous waste turn-in. If all went right, it was "only" a ten step process requiring appointments with three different agencies.

The soldier's requirements under the new system are simply to identify the material, call Public Works and assist in repackaging the material (if the material is not already in a package suitable for transporting). Today, only four steps are required to dispose of the waste, and the soldier has to work with only one agency. Public Works personnel complete all the other tasks required to dispose of hazardous waste.

Comparison of Hazardous Waste Disposal Steps: Old System vs. One Stop

Old System	One Stop
1. Order container 2. Call Public Works for guidance 3. Do paperwork 4. Call ISSD for turn-in appointment 5. Dispatch truck 6. Load truck 7. Public Works inspects 8. Get appointment with DRMO 9. Transport to DRMO 10. DRMO inspects/ receives waste	1. Unit gets training 2. Unit issued waste container 3. Unit calls for pick up 4. Public Works personnel picks up waste and delivers container to DRMO

In 1992, Fort Lewis implemented a computerized hazardous waste tracking system to track hazardous waste from the point of generation to the movement into the permitted storage facility operated by the Defense Reutilization and Marketing Office. Full operational capability of the system was reached in 1995. This system ensures compliance with the 90-day accumulation regulation. Annual modifications to this system have allowed Fort Lewis to comply with regulatory changes. Hazardous waste is only collected in containers issued, bar-coded, and tracked by Public Works. This system provides an accounting of the time hazardous waste begins to be accumulated in the container until it is disposed of through the Defense Reutilization and Marketing Office.

Program control was initially maintained by centralizing the funding of the hazardous waste disposal program with Public Works. Using the computer system, Fort Lewis now tracks disposal costs by the DODAC (Department of Defense Accounting Code), making hazardous waste disposal a reimbursable service that rewards units minimizing waste generation.

Once the waste end of the lifecycle was under control, it was possible to start moving upstream to document how the waste was generated, what process generated the waste and what materials used in the process caused the waste to be generated.

This documentation led to the development of process flow diagrams for major process areas on Fort Lewis. Materials used in the process and waste generated were identified, leading to the development of waste stream identification numbers. These numbers allow standardization of the process flow diagrams and streamline compliance reporting in hazardous waste, pollution prevention and Emergency Planning and Community Right to Know Act (EPCRA).

We knew the type of materials used in each process, and the type of waste generated in each process, but we did not know the quantity of the materials used. We needed to forecast hazardous substance use, because the hazardous material data collected from the logistics systems did not provide the detail required for compliance reporting under pollution prevention. In 1993-1994, Fort Lewis developed a forecasting tool to predict material use based on equipment and processes on post. Verified in 1995 (± 10%), and used to predict use and waste generation in 1996, this tool is used to prepare the TRI report where actual use data is not available.

In 1995, Fort Lewis developed a Business Integrated Definition model to document the current procedure to obtain, store and distribute hazardous materials. Fort Lewis also evaluated a centralized hazardous material control center as an alternative to the current logistics procurement system. This model is now being used to facilitate the reengineering of the procurement systems at Fort Lewis. In 1996, we received approval from the Command Group to begin design and implementation of the hazardous material control center (HMCC).

Hazardous materials used on Fort Lewis can be classified into two major categories: materials specified by a technical manual and materials "desired" for a specific job, or used in a specific process. Technical manual-specified materials cannot be replaced without approval from the program manager. Ban lists have been developed and include ozone-depleting substances and items that are reportable under the Clean Air Act, EPCRA, and the Pollution Prevention Program. Fort Lewis is now developing authorized use lists (AUL) for those hazardous materials that are "desired" to do a specific job. The technical manual expendable items list and the lubrication order are being used to develop the AUL for units based on equipment they are authorized to have. The ban list and AUL are dynamic documents and are updated as needed, at least once per year.

Environmental operating certificates are being developed for all organizations on post. These certificates identify current processes, materials used in the processes as specified by technical manuals, and wastes generated from the processes. Furthermore, these certificates provide the organization with an authorized use list of hazardous materials that can be procured through the hazardous material control center, a list of waste authorized for generation, and the waste stream serial number of that specific waste stream.

The implementation of the HMCC is a joint effort between Public Works Environmental Division and Directorate of Logistics Supply Division. Approval to begin implementation was received in November 1996 by the Garrison Commander. The HMCC officially opened for business 16 March 1998. This is one of the most significant actions that any facility can take to achieve "total" HM management. We have transformed from a decentralized HM procurement system to a wholly centralized one.

Directorate of Logistics (DOL) operates the HMCC. This includes centralized HM order, issue, storage; distribution to authorized users in quantities limited to immediate needs. Initially, the collection and reissue of unused serviceable HM was being done on a free issue basis. This practice has been suspended at the direction of the post accountant. A standing operating procedure (SOP) for internal and external operations has been developed.

Public Works-Environmental and Natural Resources Division (PW-ENRD) identifies products that are considered hazardous and develops a mechanism to ensure these products are managed through the HMCC. An AUL for HM is being developed based on processes within the

organization. The AUL will become the shopping list for the HMCC. PW-ENRD reviews, coordinates with Safety and Preventive Medicine, and approves requests for products not on the AUL. PW will maintain an authorized substitute list and a RUL. A HM substitution program is being developed. The overall goal is to provide the least hazardous product to the customer to do the required job.

A working group involving Finance and Accounting personnel has been established. This group is meeting quarterly to discuss issues associated with using the IFSM system, stock fund accounting, HSMS implementation, and other financial concerns. Other issues have surfaced during these meetings. Most recently, the post accountant identified that we could not offer HM through free issue. There is an existing policy that requires all HM drawn from DRMO be charged at full AMDEP price. This working group will proceed with a reengineering initiative to get this policy changed. This is an Army only policy. The success of the HMCC is dependent on the use of the free issue/ less than retail products as one means to be re-imbursable.

HSMS implementation is being supported by contract through the Army Environmental Center. HSMS Implementation formally began with the Initial Site Visit (ISV) conducted the week of December 15, 1997. The Functional Kick-Off (FKO) visit and the HSMS Implementation Technical Site Survey (TSS) was conducted concurrently during the week of February 9, 1998. The successful concurrent surveys were only possible due to extensive pre-planning by Fort Lewis, contractors supporting implementation, and Project Manager Sustaining Base Automation (PM-SBA). This effort will decrease the implementation cycle time by 30 days.

The initial operational capability (IOC) for HSMS has been defined. The supporting contractor is currently doing the Functional Implementation Process. PM-SBA will do the HSMS hardware and software installation during the week of 13 July 1998. Supporting contractors will provide HSMS training during the week of 27 July 1998. The supporting contractor inventory team will do functional implementation 20 July through 14 August 1998. IOC is currently scheduled for 14 August 1998.

IOC will only cover inventory and bar coding of HM in the HMCC, 1/37 BN, and DOL-Repair Activity Division (RAD). We currently have over 300 sites reporting HM on a quarterly basis. Our goal is to shorten the cycle time for reaching full operational capability (FOC). To achieve this, PW-ENRD is working to with the supporting contractor to identify data that can be pre-loaded into the system. We are currently doing a QA/QC check on existing data. Our goal is to do a complete preload of all organizations into the cost center module of the HSMS. This will allow us to track HM to a storage location. In addition, development of functional process links to HM usage will be completed for at least 30% of the organizations. We are standardizing processes for military units at organizational level. The goal is to develop similar processes at the DS level. By standardizing processes, FOC should be easier to achieve. In addition, using HSMS for an EPCRA reporting tool should be easier.

CONCLUSIONS

The development of a comprehensive material management program that encompasses all aspects of the lifecycle has improved the overall management of hazardous materials on Fort Lewis and has been instrumental in achieving and exceeding our pollution prevention performance goals. Tracking hazardous waste and serializing the waste streams allows Fort Lewis to stay in compliance and track reduction trends. Data collection for EPCRA reporting and implementation of the HSMS will allow us to control volumes of HM stored on post and may reduce reporting burdens. Implementation of the HMCC and HSMS tracking system will help Fort Lewis reduce the volume of HM downgraded to HW by centralizing control and enforcing operational loads.

Session XXII
Compliance Through P^2 Initiatives

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INTRODUCTION

The advent of pollution prevention (P2) as an environmental initiative has greatly expanded the options available to environmental managers in addressing environmental compliance issues. In the past, base-level P2 activities were focused on supporting Air Force goals and metrics. Unfortunately, that approach has not always addressed the needs of the installation to minimize regulatory and budget concerns, such as pollution control requirements and inspection deficiencies.

To address local regulatory issues, pollution prevention has now been added to the environmental manager's toolbox as a means of addressing these issues in a more aggressive and proactive manner. By using such P2 methods as source reduction and process modification, environmental managers now have the capacity to reduce regulatory burdens in many different areas (e.g., drinking and waste waters, spill response requirements). In the Air Force, this new approach is the subject of the August 1997 HQ USAF/ILEV policy letter, Pollution Prevention to Achieve Compliance.

The HQ USAF/ILEV policy letter directed that the P2 hierarchy is now to be used in achieving and maintaining environmental compliance. The Air Force P2 hierarchy is as follows:

- Reduce/eliminate dependence on hazardous materials and reduce waste streams (source reduction)
- Reuse generated waste and recycle waste that is not reusable (recycling)
- Employ treatment
- Dispose of waste only as a last resort (end-of-pipe treatment).

Historically, this hierarchy has been used only for ranking potential P2 projects to determine order of implementation. Now this P2 hierarchy can be used as a method for ensuring compliance, rather than driving a separate goal-driven program. Following the established hierarchy will allow the Air Force to take a proactive leadership role in reducing regulatory requirements by reducing the use of hazardous materials and the release of pollutants into the environment to as near zero as feasible. Air Force Instruction (AFI) 32-7080, Pollution Prevention Program, is currently undergoing revisions to reflect the new Air Force focus on "compliance through pollution prevention." The updated AFI 32-7080 should be final in late 1998.

INCORPORATING COMPLIANCE INTO P2 MANAGEMENT TOOLS

The compliance through P2 concept is designed to eliminate or reduce strenuous environmental compliance requirements by preventing or reducing regulated and harmful discharges into the air, land, and water at the source rather than through treatment. Reducing pollutants in the Air Force mission is the driver behind producing P2 Opportunity Assessments (OA) and Management Action Plans (MAP), the two

key requirements for a successful P2 program. The P2 OA is a systematic procedure designed to identify methods of reducing or eliminating waste or adverse environmental impacts associated with a specified process. The P2 MAP is a reference tool used to manage the actions needed to develop and execute an installation's P2 Program. The MAP incorporates opportunities identified in the OA and presents management strategies for implementation.

Historically, opportunities identified and presented in the P2 OAs and P2 MAPs addressed projects that reduced pollution and exemplified the Air Force's desire to take the lead in becoming good stewards of the environment. In previous years, the OA investigating teams would have only examined current shop processes and previous pollution program plans to identify areas where new P2 projects could be applied. Incorporating compliance into the P2 program means using compliance tools as well as typical P2 tools to identify projects not only to reduce wastes/discharges but to achieve regulatory compliance.

Earth Tech, Inc. (Earth Tech), recently completed five P2 MAPs with limited OAs and two complete OAs for various Pacific Air Forces (PACAF) installations. When performing the first step of the OA process, data collection, not only did the team assess the installations' existing P2 Plan, P2 OAs, and P2 MAP, the following compliance data was requested:

- Most recent ECAMP audit reports
- US TEAM Guide State Supplements
- Federal, State, or local Notices of Violation
- A-106 printouts for both the Compliance and P2 Programs
- Permit parameters (NPDES, Title V, Solid Waste, etc)
- Air Force and Department of Defense Instructions
- Installation-Specific Instructions

The first step in using P2 to address regulatory deficiencies is to identify those that are susceptible to P2 solutions. Not all compliance problems will have a P2 solution, and the assessment team must be able to differentiate between those not applicable and those that require "thinking outside the box" for a P2 solution.

COMPLIANCE THROUGH P2 EXAMPLES

One installation had an Environmental Compliance Assessment and Management Program (ECAMP) finding citing mismanagement of 55-gallon drums of used petroleum, oil and lubricants (POL) product. The base had a recurring problem of storage space for large volumes of used oil. The solution cited in the ECAMP document was to construct a new storage unit for the 55-gallon drums of used oil. A P2 solution would be to determine methods for reducing the quantity of oil so that extra storage would not be required. In this particular case, an oil analysis program was recommended to reduce the amount of used oil generated on the installation. The P2 solution of source reduction (reducing the amount of used oil produced) will be far more cost effective than the typical end-of-pipe solution by reducing handling and storage requirements of the used oil. Additional benefits of this solution include cost savings on virgin product, reduction in hazardous material storage regulatory requirements, and less handling of a hazardous substance, which results in less spillage and clean-up.

Another compliance finding dealt with the storage of lead-acid batteries. The concern was based on the possibility of the sulfuric acid or lead leachate contaminating a nearby drainage area. The management solution at the time of the site visit had been to construct better berms for the containment area. The recommended P2 initiative identified as a more effective solution in the P2 MAP was to replace the use of lead-acid batteries with sealed gel-celled batteries, which do not pose the environmental threats associated with lead-acid batteries.

One installation had difficulties complying with pesticide management regulations. The facility was cited for failing to have an adequate pesticide storage facility, as well as failing to have certified applicators. At the time of the compliance inspection, the facility's Pesticide Management Plan was also outdated. Large

funding requirements would have been necessary to fix these problems with the typical solutions of constructing a storage facility, sending personnel to certification courses, and updating the Management Plan to include all pesticides used on site. However, rather than implementing the typical end-of-pipe solution, the facility reassessed the need for using pesticides on the facility. After careful consideration, all pesticide use ceased and all chemicals were sent off base. Now the only type of "pesticide" used is a standard home mousetrap.

A vehicle maintenance shop was experiencing difficulty disposing of brake shoes possibly containing asbestos. Because the shop could not determine which brake shoes contained asbestos, they all had to be drummed up and sent off base for hazardous waste disposal. The shop manager said that he was also having problems finding an agency to accept the hazardous waste. The shop ended up paying a large sum of money to dispose of the brake shoes. To alleviate these disposal and handling problems in the future, the shop entered into a contract with a local brake shoe vendor. Under the contract, non-asbestos-containing brake shoes are sold to the vehicle maintenance shop and when replaced, the old shoe is returned for a new brake shoe. This one-to-one replacement has eliminated all disposal and handling requirements of asbestos-containing material for the vehicle maintenance shop.

Another installation was utilizing a dining hall freezer unit approximately four times the size needed to support the installation's food storage requirements. The freezer used power supplied by the local community and utilized three compressors containing a Class I ozone-depleting substance (ODS). Reducing the size of the freezer would reduce the installation's energy use and refrigerant requirements needed by the installation. Although the refrigerant would eventually be changed out during the ODS phaseout, reducing the size of the freezer would reduce the amount of alternate refrigerant selected to replace the Class I ODS because the smaller freezer would only require one compressor.

Besides compliance findings cited in audit inspections, permits are an excellent source to identify P2 solutions. Check your installation's National Pollutant Discharge Elimination Systems (NPDES) parameters and determine the source of the pollutants. Can this source be eliminated or can the pollutants be reduced? Once this is done, permits should be changed to reflect this to avoid a higher discharge standard and the regulations that govern them.

Another method often overlooked is the A-106 for the compliance program. Most installations have different individuals running the compliance and P2 program. Therefore, the P2 manager does not typically view the compliance requirements identified in the A-106. By working with the compliance manager, projects that could eliminate a compliance funding requirement can be identified. As an example, had the excess storage problem of used oil mentioned above not been identified in the ECAMP document, the P2 manager still would have identified a P2 opportunity by noticing a construction requirement on the compliance A-106.

CONCLUSION

All of the compliance tools mentioned can assist the installations' P2 Manager and P2 OA teams in identifying P2 options that will most likely be validated by the Major Command (MAJCOM) due to the compliance benefits. With the advent of "compliance through P2," opportunities that once seemed too expensive or not cost effective will now appear more attractive because recaptured compliance costs can be factored into the cost analysis.

It should be noted that identifying "compliance through P2" projects are more difficult when performing an installation-wide OA or compliance assessment. In order to obtain an in-depth study of P2 solutions for a compliance problem, the installation should target one compliance issue at a time. This will ensure a usable, thorough, P2 alternative for a regulatory requirement.

Incorporating compliance into the installation P2 OA and P2 MAP creates documents that can be used by the entire environmental flight to ensure compliance **and** environmental stewardship. The P2 documents,

once viewed only as "nice to have" documents in order to achieve Air Force goals, now can truly be used as proactive "must have" drivers for the entire environmental program.

IMPLEMENTATION OF PROCESS/EQUIPMENT CHANGES TO REDUCE METAL HYDROXIDE/MIXED SLUDGE DISPOSAL AT TINKER AFB

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ABSTRACT

The industrial wastewater treatment plant (IWTP) at Oklahoma City Air Logistics Center (OC-ALC), located at Tinker AFB, produces a "mixed sludge" as a result of treatment of wastewater to remove organic, heavy metal, and other contaminants. This sludge is disposed as a hazardous sludge at a cost averaging $250,000/yr over the last 3 years. To reduce the cost of sludge disposal as well as to meet P2 goals of reducing off-site waste discharges, Tinker AFB initiated a program three years ago to develop and demonstrate suitable processes and equipment changes to achieve these goals. The program was successfully completed earlier this year and it exemplifies compliance through P2 approach.

An analysis of the IWTP operation revealed that the metals treatment section of the plant was using high dosages of chemicals leading to formulation of large volumes of sludge as well as producing poor quality effluents. To address these problems, two different process chemistries were evaluated and changes in equipment and operating procedures were examined. The $FeSO_4$/NaOH process was replaced with the NaHS/$FeSO_4$ process to reduce the formation of sludge by about a factor of about two. Additionally, the operating procedures were refined to avoid adding excessive quantities of NaHS and $FeSO_4$. To utilize these new operating procedures, some equipment changes were made to better control chemical additions. Finally, a new process for sludge handling was adapted to further reduce the quantity of sludge disposal.

Full-scale trials of process/equipment changes, completed in January 1998, showed that the quantity of sludge disposed could be reduced by over 60 percent, saving over $170,000 per year. The effluent water quality has been improved and chemical costs have declined. The plant is continuing to practice the process/equipment changes. Recommendations for future improvements were also made. The process changes are applicable at a DoD-wide level.

INTRODUCTION AND BACKGROUND

OC-ALC is committed to reducing the amount of hazardous waste discharged off-site by 50 percent by CY99 relative to CY92 baseline. A key contributor of hazardous waste is the mixed sludge produced in the IWTP. This sludge, an F-waste, is a mixture of metal hydroxide

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sludge from metals treatment section of the IWTP and biosludge from the BOD reduction section of the IWTP. During the last three years (FY's 95, 96, and 97), OC-ALC disposed an average of 1.12×10^6 lbs/yr of thickened (about 10 percent solids), mixed sludge and 0.37×10^6 lbs/yr of de-watered (about 30 percent solids), mixed sludge. The average total disposal cost for these sludges was $249,000/yr. The reason for disposal of a large amount of non-dewatered sludge was that the filter press operation was unsatisfactory.

The IWTP typically receives and treats 900,000 gallons per day of wastewater. The key unit operations in the IWTP are: (a) oil/water separation, (b) metals reduction and precipitation, (c) biotreatment for removal of organics, (d) thickening, conditioning, and dewatering/filtration of a mixture of metal hydroxide sludge and biosludge, and (e) pH adjustment and final filtration of the treated wastewater. The objective of this two-phase project was to identify, develop, and demonstrate suitable process and equipment changes in operations (b) and (d) to cost-effectively reduce the quantity of sludge disposed.

APPROACH

The approach consisted of two steps. First, the relevant processes and equipment were monitored and evaluated along with some exploratory bench- and pilot-scale testing. The preferred process/equipment changes were then evaluated at full-scale and implemented. Battelle worked closely with numerous OC-ALC staff during the implementation phase.

The IWTP operations evaluated included three chemical addition basins, two solids contact clarifiers (SCCs), and a sludge conditioning/dewatering system. Liquid samples were taken at the feed to metals treatment section and at the discharge of the SCCs. These samples were analyzed for oil and grease (O&G), RCRA metals, and total suspended solids (TSS). These analyses provided data to determine the performance of the new metals treatment process. Jar testing was performed to duplicate the process and to determine the effect of various chemical addition rates and the impact of various polymers on the generation of flocs and water turbidity. Solid samples were taken from the sludge holding tank and from the filter press after filtration/dewatering.

Observations of the IWTP were made and information was gathered from interviews with plant operators from each shift. Design information, written plant operating procedures and manuals, and operating data were reviewed. This information established baseline operational procedures, and was used with background knowledge of typical unit operation performance in wastewater treatment service to determine potential changes that could be made to improve plant operation and performance.

During the exploratory testing phase, jar testing was conducted to screen polymers that would improve the water turbidity and improve settling of the solids in the SCC. Several other process/equipment changes to improve metals treatment were evaluated. And pilot plant tests were carried out using improved sludge dewatering methods. During the process/equipment implementation phase, several equipment changes for metals treatment and sludge dewatering were made and the process/equipment changes were evaluated. Based on the results of the full-

scale testing and other analyses, a revised operating procedure for metals treatment and mixed sludge dewatering was developed.

IMPROVEMENTS IN METALS TREATMENT

At the beginning of the Phase II effort, the metals treatment section of the IWTP (a) was using high dosages of chemicals, including polymers, (b) had a high effluent turbidity, and (c) was producing excessive amounts of metal hydroxide sludge. To address these problems, OC-ALC and Battelle evaluated and adapted an alternative metal precipitation chemistry and improved chemical and polymer addition process and equipment.

Alternative Chemistry

The existing process for removal of hexavalent chromium (Cr^{VI}) and other RCRA metals was based on the $FeSO_4$/NaOH chemistry. This process operated at a pH of about 9.5 which, on a theoretical basis, requires 3 moles of $FeSO_4$ for every mole of Cr^{VI}. This not only produces a large amount of $Fe(OH)_3$ sludge but also requires neutralization of the treated water. This process also requires a FeS treatment system downstream for achieving low levels of Cr^{+3} in the effluent. The alternative chemistry, on the other hand, consists of using a combination of NaHS and $FeSO_4$ at a near-neutral pH. The theoretical amount of sludge thus produced is roughly 43 percent of the sludge produced in the previous process[1]. The need for polishing treatment for Cr^{+3} is also avoided as the use of iron salts in the new process results in complexation reaction with other metals, such that lower than theoretical metal solubilities based on hydroxide alone or sulfide alone processes can be achieved. Thus, the process is simplified. Therefore, the plant was switched over to the new chemistry. Both the jar tests and full-scale tests showed all metals of concern to be below allowed discharge limits. Similar results have been reported in a previous Air Force Study[1] in 1988 and more recently in a study by the Navy[2].

As the influent metal concentrations have greatly declined since the IWTP was designed, it was necessary to make adjustment in chemical feed rates. Based on jar tests, a new set of feed rates were established to achieve the required effluent quality as well as to maintain an active sludge blanket for capturing the precipitated hydroxide particles. It also was necessary to switch to smaller chemical metering pumps to avoid overdosing.

Flocculation Improvements

While the new metals precipitation chemistry produces less sludge, on a dry basis, it requires more attention to flocculation because of the finer nature of the precipitate formed. In particular, it was necessary to avoid overdosing of polymers as well as to properly condition the two polymers. A combination of cationic (Betz 1195) and anionic (Drew 270) polymers was satisfactorily demonstrated with the new chemistry.

Two new polymer blending/conditioning systems were installed and tested for minimizing polymer use and for better control of the polymer feed rates. An alternative polymer combination of PP1075 (cationic) and Drew 270 (anionic) was also satisfactorily tested and specified as a backup.

Both polymer systems helped reduce the effluent suspended solids (TSS) levels from as high as 17 ppm to about 5 ppm. This reduced the overloading and consequently the frequent backwashing of the multi-media pressure filters. These backwash solids eventually settle in the equalization basins ahead of the metals treatment and make a voluminous sludge. In fact, it is estimated that a 1 ppm reduction in effluent TSS reduces equalization basin sludge disposal cost by $12.10/day. The cost of either polymers system was about a third of this. Furthermore, the reduction in backwashing frequency helped reduce plant operator attention to this operation.

IMPROVED SLUDGE DEWATERING

An analysis of the sludge conditioning and filter press operation showed that much improvement was needed to more completely and reliably dewater the sludge. The existing operation employed a cumbersome $FeCl_3$/lime sludge conditioning process and caused frequent filter cloth blinding. An alternative conditioning process based on the use of perlite, a naturally occurring filter aid was identified. After extended pilot testing, the process was implemented on full-scale. To minimize operator involvement, the process of perlite loading and feeding was simplified and mechanized (Figure 1).

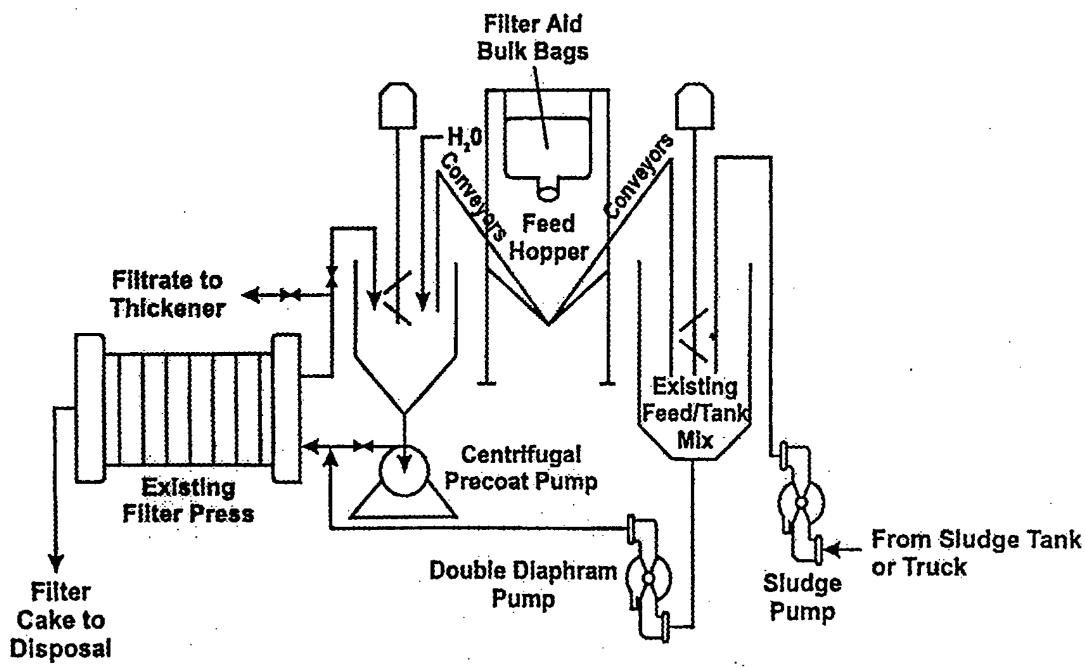

Figure 1 Sludge Dewatering Process Flow Diagram.

The results of seven sludge dewatering tests are summarized in Table 1. The first three tests confirmed that the use of a perlite precoat improved the $FeCl_3$/lime treatment process by reducing filter blinding. The last four tests confirmed that the $FeCl_3$/lime process could be eliminated by use of perlite as a body feed. The typical range for filter cake solids content was 30 to 40 percent, with the feed sludge being at 6 to 14 percent solids. Based on these results, OC-ALC decided to replace the $FeCl_3$/lime treatment process with the simple perlite addition.

An economic analysis of the previous and the new processes was performed. At a perlite precoat rate of 0.033 lb/gallon of feed and a perlite body feed rate of 0.18 lb/gallon of feed, the cost savings are estimated to be $170,000/yr. At a capital cost investment of $175,000, this provides a payback period of about 12 months. The corresponding reduction in off-site sludge disposal weight, even if we assume that metal precipitating chemistry changes do not significantly reduce the amount of metal hydroxides formed, is estimated to be 62 percent.

It was determined that this improved sludge conditioning/dewatering system could also be used to dewater an oily sludge, which until now had been disposed without any dewatering. Thus, the same investment in capital cost also has the potential of saving about $380,000/yr for oily sludge disposal. This potentially reduces the payback period to 4 months.

TABLE 1. FULL-SCALE SLUDGE CONDITIONING/DEWATERING TESTS

	Test Conditions				Total Suspended Solids (TSS) wt.%		
Test No.	**Gallons of Sludge Dewatered**	**$FeCl_3$/lime Treatment**	**Precoat lb/gallon Sludge**	**Perlite Body Feed, lb/gallon Sludge**	**Feed**	**Filter Cake**	**Comments**
1	3,000	Yes	0.033	0.58	14.08	29.70	
2	3,000	Yes	0.033	0.58	11.30	36.23	
3	3,000	Yes	0.05	0.58	ND	38.09	
4	3,000	No	0.05	0.40	10.53	34.13	
5	10,000	No	0.015	0.18	ND	43.40	Mixed with some oily-sludge
6	10,000	No	0.015	0.18	ND	32.20	Mixed with some oily-sludge
7	10,000	No	0.015	0.18	6.20	29.10	Mixed with some oily-sludge

ND: Not determined.

CONCLUSIONS

This project demonstrated that substantial compliance cost savings can be achieved through suitable process and equipment changes. Specifically, (a) the use of $NaHS/FeSO_4$ for Cr^{VI} and metals precipitation, (b) optimization of chemical and polymer feeding, and (c) the use of perlite as a filter aid as well as a body feed was successfully implemented. The overall IWTP operation was simplified and the quantity of sludge disposed was cost-effectively reduced by at least 62 percent.

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ALTERNATIVES TO ENFORCEMENT ACTIONS: THE USE OF POLLUTION PREVENTION SUPPLEMENTAL ENVIRONMENTAL PROJECTS

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INTRODUCTION

In the Pollution Prevention Act of 1990, Congress put the concept of preventing waste at the source into law. The Act states that pollution "should be prevented at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner." While this act established the waste management hierarchy, it did little to encourage either facilities or regulators to move away from the "end-of-pipe" treatment mentality. While innovative EPA programs such as the Common Sense Initiative, Project XL and the Green Chemistry Challenge have been positive steps, the participating companies are generally large and currently environmental leaders. The question of how to get small to medium facilities and environmentally challenged firms to implement pollution prevention techniques has yet to be answered. An attempt to bridge this gap has been the development of the EPA program on the use of Supplemental Environmental Projects.

Supplemental Environmental Projects (SEPs) allow facilities that violate environmental regulations to minimize the imposed fines in exchange for the implementation of an environmentally beneficial project. (Note: The fine is not totally eliminated. Generally, the company is required to pay what is considered the "economic benefit" portion of the fine, specifically, the money saved by being out of compliance.) The amount the penalty is reduced is the minimum amount of capital that must be applied to the proposed project. Typically, the cost to implement a project exceeds the amount of the penalty reduction.

SUPPLEMENTAL ENVIRONMENTAL PROJECT GUIDELINES

EPA has defined SEPs as "environmentally beneficial projects which a defendant/ respondent agrees to undertake in settlement of an enforcement action, but which the defendant/respondent is not otherwise legally required to perform." To be *environmentally beneficial*, a SEP must "improve, protect or reduce risks to public health or the environment at large." While some violators will experience certain benefits from the projects, the project must primarily benefit public health or the environment. EPA considers projects to be *in the settlement of an enforcement action* when EPA has "the opportunity to help shape the scope of the project before it is implemented and the project is not commenced until after the Agency has identified the violation." While SEPs may include activities which facilities will be legally obligated to undertake two or more years into the future, the SEP cannot include any action which is otherwise required by any federal, state or local law or regulation.

EPA has set up five legal guidelines on the use of SEPs to ensure the proposed project is within the Agency's authority and does not conflict with any statutory requirements. First, all projects must have a nexus (relationship) between the violation and the proposed project. This means the project must reduce or remove the environmental or public health impacts to which the violation contributes, or reduce the likelihood of similar violations in the future. A nexus applies if the project occurs not only at the site of the violation, but at a different site within the same ecosystem or within the immediate geographic area (generally within a 50 mile radius of the site of the violation). Some states have made changes to the nexus requirement to allow more flexibility to be creative when evaluating SEPs. Second, the project must advance at least one of the declared objectives of the state environmental statutes. Third, EPA or any other federal agency may not manage the funding of the project or be responsible for the administration of the SEP. EPA may provide oversight to ensure that implementation meets the provisions of the settlement. EPA will maintain the right of legal recourse should the SEP not be adequately completed. Fourth, the type and scope of the SEP will be determined in a signed settlement agreement. And fifth, the project cannot be something EPA itself is legally required to complete, includes providing EPA with additional resources to perform an activity or expanding an existing EPA program.

APPROVED SUPPLEMENTAL ENVIRONMENTAL PROJECT CATEGORIES

EPA currently has designated seven categories of projects which may qualify as SEPs.

1.) Public Health which provides diagnostic, preventative and/or remedial health care which is related to the actual or potential damage to human health caused by the violation. Public Health SEPs are acceptable only where the benefit of the project is to the population that was harmed or put at risk from the violation in question.
2.) Pollution Reduction focuses on waste streams that have already been generated or released and reductions in future violations through recycling, treatment, containment

or appropriate disposal. This may include the installation of end-of-process control or treatment technologies, or rather "end-of-pipe solutions."

3.) Environmental Restoration and Protection going beyond repairing damage caused by a violation to actually enhance the condition of the ecosystem or immediate geographic area adversely affected past the baseline conditions. This may be to restore or protect natural environments or man-made environments such as facilities and buildings. Man-made improvements may also include removal/mitigation of contaminated materials such as soil, asbestos and leaded paints.

4.) Assessments and Audits including pollution prevention assessments, site assessments, environmental management system audits and compliance audits if not already available as injunctive relief. In most cases, the SEP will include an agreement to implement all findings. Pollution prevention assessments are systematic, internal reviews of processes and operations to identify opportunities to reduce the use, generation and/or production of toxic and hazardous wastes. The assessments must be done using a recognized procedure and experienced personnel. Site assessments investigate the current conditions of the environment or the risk to the public health at the site or the environment impacted by the site. Environmental management system audits are independent evaluations of a facility's environmental policies, practices and controls. Environmental compliance audits are an independent evaluation of the facility's compliance status with all federal requirements and are generally only acceptable when the defendant/respondent is a small business.

5.) Environmental Compliance Promotion provides training or technical support to other members of the regulated community to a) identify and achieve compliance with the regulatory requirement associated with the violation; b) avoid commitment of a similar violation; or c) go beyond compliance by reducing the generation, release or disposal of the related pollutants beyond the legal requirements. This education must be focused on the same regulatory requirements that were violated and would advance compliance in the industrial sector affected by the proposal.

6.) Emergency Planning and Preparedness provides assistance in the form of computers and software, communication systems, chemical emission detection and inactivation equipment, HAZMAT equipment, or training to a responsible state or local emergency response or planning entity in the district or state affected by the violation.

7.) Pollution Prevention which reduces the generation of waste through source reduction including equipment or technology modifications, processor procedure modifications, reformulation or redesign of products, substitution of raw materials and improvements in housekeeping, maintenance, training, inventory controls or other operation and maintenance procedures. Pollution prevention also includes any project which protects natural resources through conservation or increased efficiency in the use of energy, water or other materials.

POLLUTION PREVENTION SUPPLEMENTAL ENVIRONMENTAL PROJECT

SEPs that target pollution prevention (P2SEP) are preferred by EPA and receive greater consideration than the other six categories. Currently, the definition of a P2SEP is "an environmentally beneficial project that a violator agrees to undertake in consideration of a penalty offset from an enforcement action that incorporates pollution

prevention as the primary objective, and that must be performed as part of the legal requirements established in the settlement of the enforcement action, but is not otherwise legally required to be performed."

Projects that are not acceptable as P2SEPs include general educational environmental awareness projects, contributions to environmental research at a college or university, a project beneficial to a community but unrelated to environmental protection, studies or assessments without an agreement to implement the results and/or projects which are funded by low interest federal loans, federal contracts or federal grants.

PROCEDURAL GUIDELINES

Although not all enforcement cases are suitable for P2SEPs, the consideration of pollution prevention opportunities is available in all enforcement actions. Once an agreement between the violator and the Agency has been reached regarding a P2SEP, the violator should conduct a waste assessment. The assessment will ensure that the conceptual project is applicable and technically feasible to implement. Waste assessments generally include a list of operational procedures for each production step, a process flow diagram, an inventory of all raw materials on-site, a detailed listing of all toxic and hazardous substances generated, amounts of all waste on-site, a materials balance on all process streams, a maintenance survey and a summary of all regulatory permits.

While this process is similar to the Assessment and Audit SEP, no agreement will be made to implement waste minimization opportunities developed. Should such an agreement be reached, additional consideration on reductions would be made during calculation of the final penalty. Costs incurred by a violator in implementing a SEP are usually considered in determining an appropriate settlement amount.

PENALTY OFFSET CALCULATIONS

Calculating a final penalty in a settlement including a P2SEP includes three phases: the Agency penalty; calculation of the cost of the SEP; and penalty mitigation. A substantial Agency penalty is generally required for legal and policy reasons. *Not including the P2SEP*, the penalty will recover at a minimum the greater of the economic benefit of noncompliance plus 10 percent of the gravity component, or 25 percent of the gravity component only. The net present amount after tax cost of implementing a P2SEP is calculated by the facility. These costs generally include capital costs, such as equipment, one-time nondepreciable costs associated with things like clean-ups or land purchase and annual operating costs or savings incurred after P2SEP changes are made. The penalty mitigation phase uses the information provided by the company in estimating implementation costs to determine the amount the Agency penalty may be offset. Currently, the EPA statutes recommend a penalty mitigation related to 80 percent of the cost to implement general SEP, however P2SEPs are encouraged by a recommended 100 percent offset of implementation costs. However, P2 projects typically result in cost savings. While P2SEPs are encouraged, the proposed project should be one that the

violator would not normally implement without the enforcement action. To address this issue during penalty mitigation, many states have set up a detailed payback analysis. Projects are only approved if they fall outside a set payback period (in years). Projects inside the period are reasoned as being implemented regardless of whether a penalty offset is received. Some states grant additional offset based on a determination of the benefits to public health or the environment, innovativeness of the technology, environmental justice, multimedia impact and volumes of pollution prevented.

After the penalty mitigation, a P2SEP plan will be generated. This plan will be incorporated into the Consent Agreement and Order. The plan should include the pollutant and media to be addressed, a detailed cost estimate and project completion schedule, a list of contractors and/or consultants assisting with the project, a schedule of report submittals and other pertinent information. An essential part of the packet is financial data which illustrates that the company has sufficient financial resources to implement the project. An SEP of any type will be rejected if the facility is deemed financially unstable to see the project to completion.

Other possible reasons for rejection of a P2SEP include: facility operations have little potential for P2; upper management is not interested in implementing P2 activities; penalty amount is too low for significant funds for a P2 project; the P2 project is so large the regulatory agency does not have sufficient resources to oversee the project and verify implementation; or the violator has an extended history of noncompliance and has not been cooperative. Some states have found P2SEPs extremely useful to bring repeat offenders into compliance.

CONCLUSION

In the future, the use of SEPs and specifically P2SEPs, will be encouraged by EPA and state regulatory programs. While EPA deems penalties important in environmental protection by deterring violations and creating a level playing field, SEPs have been recognized as playing a role in developing significant environmental and/or public health protection and improvements. SEPs may also help to further other EPA objectives including promoting pollution prevention and addressing environmental justice. Therefore SEPs involving pollution prevention techniques will always be preferred over other types of reductions or control strategies.

Session XXIII
Environmental Preferred Substitutions

Session Chairpersons:

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Pollution Prevention: Identification of Environmentally Preferable Paints

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Demonstrating environmental leadership, Aberdeen Proving Ground (APG) identified environmentally preferable paints from among some 1,300 products used on the installation. This was an essential step in fulfilling the Army's mandate to purchase environmentally preferable products under Executive Order 12873 and Federal Acquisition Regulations, Part 23.

Approach

APG contracted with Green Seal, a nonprofit testing and rating service, to identify environmentally preferable paint standards. The ingredients identified in the material safety data sheet (MSDS) for paints currently in use at APG were evaluated against these new APG environmental standards for paint. All paints tested were already in compliance with current federal and state regulatory standards. Paints that met the APG standards (i.e., contained no prohibited compounds) were then tested for volatile organic compounds (VOCs) by Aberdeen Test Center. The center used U.S. Environmental Protection Agency (EPA) Reference Test Method 24, Determination on Volatile Matter Content, Water Content, Density Volume Solids, and Weight Solids of Surface Coatings, CFR Title 40, Part 60 Appendix A. A list of paints that met the standards and passed VOC tests was distributed to APG purchasers as an example of paints that minimize adverse effects on the environment.

Background

Volatile Organic Compound Restrictions

Volatile organic compounds (VOCs) are organic compounds with a vapor pressure greater than 0.1 millimeter of mercury at 25 °C, as determined by ASTM D3960, Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings. Compounds excluded from

this definition are methane, carbon monoxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

All oil-based paints and most water-based paints contain organic solvents that disperse and carry the other paint components and accelerate drying of the applied paint. Traditional oil-based formulas contain 40% to 60% organic solvents while water-based paints contain 5% to 10% organic solvents. These solvents contain VOCs that have been identified as significant contributors to the formation of ground-level ozone and photochemical smog. Unlike the stratospheric ozone protecting the earth from harmful radiation, excessive ground-level ozone is harmful to plant and animal life.

Ground-level ozone is produced when its precursors, VOCs and nitrogen oxides (NOx), combine in the presence of sunlight. While architectural coatings in total contribute less than 2% of the more than 25 million tons of VOCs annually released in the United States, their concentrated use in urban areas significantly contributes to ground-level ozone formation and exacerbates health problems due to degraded air quality.

Due to the documented health risks associated with high VOC levels, APG has set stringent standards (table 1).

Table 1. APG VOC Limits for Paints

Type of Paint	VOCs (grams/liter)	VOCs (pounds/gallon)
Interior architectural		
Flat	50 g/l	0.42 lb/gal
Non-Flat	150 g/l	1.25 lb/gal
Exterior architectural		
Flat	100 g/l	0.83 lb/gal
Non-Flat	200 g/l	1.66 lb/gal
Anticorrosive		
Flat	250 g/l	2.1 lb/gal
Semi-Gloss	250 g/l	2.1 lb/gal
Gloss	250 g/l	2.1 lb/gal

Inorganic Component Restrictions

Paints often contain inorganic and organo-metallic components used as preservatives, additives, and pigments. Table 2 lists the base inorganic components prohibited by APG standards.

Table 2. Inorganic Components Prohibited by APG Standards for Paints
Antimony
Cadmium
Hexavalent chromium
Lead
Mercury

Though lead was once commonly used in several components in paint, its use in recent years has been curtailed. The highly toxic nature of lead and its historically pervasive use in plumbing fixtures, solders, gasoline additives, and paint has contributed to establishing lead poisoning as the number one neurotoxic disease in this country. While the intentional use of lead has been phased out, its presence is still allowed up to 0.06% for surface architectural coatings (16 CFR Part 1303).

Lead and mercury attack the central nervous system (CNS) and cause CNS depression as well as severe damage to the liver and kidneys. Lead is especially known for its severe toxic effects on children. Mercury has variable effects on the brain, including personality changes, tremors, and vision, hearing, and memory problems. Short-term exposure is often associated with damaged lungs, nausea, vomiting, diarrhea, increased blood pressure, and dermal and eye irritation.

Proscribed Organic Compounds Found in APG MSDSs

Organic chemical compounds in paint affect a number of paint characteristics from how smoothly the paint flows to its freeze resistance. Table 3 lists all compounds prohibited by APG standards.

Table 3. Organic Compounds Prohibited by APG Standards for Paints

Methylene chloride	Di-n-butyl phthalate
1,1,1-trichloroethane	Di-n-octyl phthalate
Benzene	Diethyl phthalate
Toluene (methylbenzene)	Dimethyl phthalate
Ethylbenzene	Isophorone
Vinyl chloride	Formaldehyde
Naphthalene	Methyl ethyl ketone
1,2-dichlorobenzene	Methyl isobutyl ketone
Di (2-ethylhexyl) phthalate	Acrolein
Butyl benzyl phthalate	Acrylonitrile

These compounds pose widespread environmental and health concerns and many are on the high-priority list for EPA's 33/50 program. Paints containing the chemicals discussed below are not considered environmentally acceptable under the APG standard.

Methyl ethyl ketone (MEK) (2-butanone) is restricted because of its environmental and health effects. MEK causes CNS depression as well as upper respiratory tract irritation, nausea, dizziness, and headaches. MEK can also damage the liver and kidneys, and its photochemical reactivity makes it a dangerous precursor to smog.

Benzene usually enters the atmosphere from emissions and exhaust associated with gasoline use or production. Benzene is a known human carcinogen. It also has an accelerated photochemical reaction when in the presence of typical atmospheric pollutants such as nitrogen oxides and sulfur dioxide.

Di-2-ethylhexyl-phthalate (DEHP) is considered slightly to moderately toxic, causing CNS depression as well as dermal, respiratory, gastrointestinal, and esophageal irritation.

Dibutyl phthalate (DBP), considered toxic by all routes (dermal, ingestion, and inhalation), reacts photochemically in the atmosphere and degrades to hydroxyl radicals.

Toluene severely effects the brain. Long-term exposure can cause problems with speech, vision, hearing, muscle control, memory, balance, and general mental ability. Toluene also effects the kidneys, liver, and CNS in test animals. At this time EPA has not classified toluene by its carcinogenicity; however, they have placed it on their list of priority pollutants.

Findings

Thirty-six of the 178 paints evaluated met APG standards (i.e., they contained no prohibited compounds). Of the 36, 31 were available to be tested for volatile organic compounds (VOCs). Review statistics are shown in table 4.

Table 4. Statistics for Reviewed Paints

Element	Quantity
MSDSs examined	130
Paints evaluated	178
Paints eliminated by ingredients and/or VOCs	126
Paints "out of business" or "no longer made"	16
Paints qualified for VOC testing from MSDSs	36
Paints qualified for VOC testing but unavailable	5
Paints tested for VOC levels	31

Twenty-four paints in a variety of finishes were found environmentally acceptable under APG standards. None of the anticorrosive paints tested had acceptable VOC levels. While the federal government neither endorses nor recommends any specific brands of paint, tables 5 and 6 list the results for those paints in use at APG that tested environmentally acceptable. There may be additional paints, not in use at APG, that would also meet the APG standard.

Table 5. Examples of Environmentally Acceptable Interior Architectural Paints

APG ID	Manufacturer	Product Code	Paint Name	Stated VOCs	Tested VOCs
			Flat - APG standard - 50 g/l		
60221	Benjamin Moore	212	Pristine FLAT	26 g/l	12 g/l
60269	Duron	7420226	Texture Paint FLAT	27 g/l	14 g/l
	Sherwin-Williams		Style Perfect FLAT	47 g/l	49 g/l
62136	Benjamin Moore	258	Moore's Ceiling White FLAT	37 g/l	51 g/l
			Semi-gloss - APG standard - 150 g/l		
60220	Benjamin Moore	213	Pristine EGG	23 g/l	16 g/l
61940, 60226, 60206	Benjamin Moore	214	Pristine SG	18 g/l	20 g/l
72519	Sherwin-Williams		ProMar 700 SG	62 g/l	52 g/l
35375	Benjamin Moore	215	Regal SATIN	50 g/l	68 g/l
37644.01	Sherwin-Williams		Style Perfect SG	103 g/l	76 g/l
60210	Benjamin Moore	322	Moore Kitchen & Bath SATIN	74 g/l	81 g/l
60398.31	Sherwin-Williams		ProMar 200 SG	142 g/l	86 g/l
60398	Sherwin-Williams		ProMar 400 SG	103 g/l	99 g/l
60270	Duron	53 Line	Pro Kote SG	137 g/l	112 g/l
37645.01	Sherwin-Williams		Style Perfect SATIN	119 g/l	125 g/l
			Gloss - APG standard - 150 g/l		
57382	Duron	25 Line	Deluxe GLOSS	126 g/l	117 g/l

Table 6. Examples of Environmentally Acceptable Exterior Architectural Paints

APG ID	Manufacturer	Product Code	Paint Name	Stated VOCs	Tested VOCs
			Flat - APG standard - 100 g/l		
59528	Benjamin Moore	171	Moorcraft FLAT	35 g/l	80 g/l
74215	Benjamin Moore	023	Fresh Start Ext. Primer	31 g/l	92 g/l
			Semi-gloss - APG standard - 200 g/l		
59512	Benjamin Moore	170	Moorcraft SATIN	214 g/l	111 g/l
55143.12	Sherwin-Williams		Super Paint SATIN	108 g/l	129 g/l
15633.24	Sherwin-Williams		A-100 EXT SATIN	133 g/l	158 g/l
73404	Benjamin Moore	122	Moore EXT Floor & Patio	155 g/l	176 g/l
50884	Benjamin Moore	096	Moorglo House and Trim EXT NF	210 g/l	191 g/l
71954	Duron		Weathershield SG	173 g/l	203 g/l
			Gloss - APG standard - 200 g/l		
15633.37	Sherwin-Williams		A-100 GLOSS	155 g/l	107 g/l

Information provided by manufacturers in the MSDSs varied in substance and form. VOC test results differed by as much as three times that stated. VOC levels were lower than the manufacturer's stated value for 42% of the paints and higher than the manufacturer's value for 58% of the paints.

Ninety-four paints, 53% of the total evaluated, failed the VOC tests. Fifteen paints, nearly 10%, contained a lead compound, which is prohibited for its known toxicological effects on humans. Seventeen paints were rejected because of the presence of one or more prohibited organic chemical components. For example, 10 contained methyl ethyl ketone (MEK), 9 contained toluene, and 4 contained ethyl benzene.

Conclusions

An assortment of environmentally acceptable paints, in a variety of finishes, are in use at APG. The paints are manufactured by three sources, providing opportunity for competitive procurement. There may be additional paints that were not tested because they were not in use at APG, which never the less meet the APG standard. Restricting purchases to those that meet the environmentally preferable paint standards will enable APG to meet its mandate to minimize the effect of paints on the environment.

Based on the conclusions, APG expects to use the final standards as the basis for all procurements. APG will circulate its paint standard to all units and tenants and ask buyers to adhere to them while, at the same time, reminding them of proper paint disposal measures.

Updating the Alternative Material Selection System for Cadmium (AMSS-Cd)

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Abstract

Federal specification QQ-P-416 is used to specify cadmium plating for Army applications. Cadmium, which is currently used on many military applications to provide corrosion protection, is a hazardous material. Since it has been identified as a hazardous material, cadmium has been targeted for complete removal from Army weapon systems. Unfortunately, there is no "drop-in" replacement for cadmium. Users must choose from a variety of alternatives to suit their specific needs. With the support of the Army Acquisition Pollution Prevention Support Office (AAPPSO), the U.S. Army Tank-Automotive & Armaments Command's (TACOM) Tank-Automotive Research, Development and Engineering Center (TARDEC) and Ocean City Research Corporation (OCRC) created an Alternate Material Selection System for Cadmium (AMSS-Cd) to assist in selection of alternative materials.

The original version of the AMSS-Cd was created from available physical and performance data. Some areas were found where information is unavailable. TACOM-TARDEC sponsored three projects over the past year to update the AMSS-Cd where information is needed. These efforts included: (1) evaluating cadmium replacements for electrical connectors, (2) evaluating cadmium alternatives for fastener applications, and (3) testing of possible chromate conversion coating replacements to enhance the performance of cadmium alternatives.

Information gained from these programs added more in depth information to the applications sections of the AMSS-Cd. This information both reinforced and updated previous knowledge contained in the working document.

Introduction

Executive Order 12856 mandates that the Department of Defense (DoD) reduce their hazardous waste generation 50% by 1999. Cadmium is used on Army weapon systems as a corrosion control coating for steel and aluminum. Cadmium is a carcinogenic material and has low worker exposure and environmental discharge limits due to its high toxicity. Cadmium contributes to hazardous waste generation for Army depot facilities and contractors during both plating operations, and repair/overhaul procedures.

In "Guidance for Eliminating Cadmium from U.S. Army Weapon Systems" (see ref.), AAPPSO estimated cadmium hazardous waste handling and disposal costs for the U.S. Army. There are some very significant costs and risks associated with the continued use of cadmium in U.S. Army weapon systems that will not only affect the life cycle cost of the systems, but may also affect readiness and fielding capabilities in some extreme circumstances. Two of the costs are sited below:

- OSHA has set a 5 ppm 8-hour time weighted permissible exposure limit (PEL) for cadmium. Depots are required to upgrade their facilities to comply with the new regulations. One depot has committed $22M for an entirely new, OSHA-complying metal finishing facility. A second will reportedly spend $275K to upgrade an existing facility to provide shower and clean-up areas required for employees exposed to cadmium.

- Hazardous waste disposal costs for cadmium at one Army depot were estimated to be $60,000 per year for treatment and disposal. This does not include administrative costs associated with compliance with RCRA, or any possible additional ordinances imposed by the state or local government.

The Alternate Material Selection System for Cadmium (AMSS-Cd) was developed as a tool to help guide design and material engineers along the process of identifying an appropriate non-cadmium material for U.S. Army weapon systems. Version 1 of this system focused on the use of cadmium in plating applications. The primary types of alternate materials discussed in the system provide sacrificial and barrier corrosion protection to steel and aluminum substrates in typical Army weapon system environments, just as cadmium provides. Additional coatings that provide only a barrier to keep corrosive environments from substrate materials and alternate base materials were also briefly mentioned in the system because they are appropriate alternatives for some applications.

The AMSS-Cd requires the user to understand the requirements of the application they are examining. It then gives suggested alternate materials and accompanying specifications. Industry standards or commercial specifications have been identified when possible to assist the DoD's efforts to move away from the use of military specifications and standards. The system is a guide to help the user select an alternate material. It is not intended to be Army policy, but rather it is intended to provide guidance to the decision-maker. ***The responsibility for ensuring that the appropriate coating is selected ultimately falls upon the user of the AMSS-Cd.***

The AMSS-Cd is meant to be a living document, undergoing revision, as new materials are constantly being developed and their properties are being evaluated. Periodically, the AMSS–Cd document is meant to be revised to include all additional information. (All constructive criticism or sharing of additional test data associated with the AMSS-Cd is appreciated and comments can be forwarded to either of the paper's authors.)

Alternate Material System for Cadmium (AMSS-Cd)

The AMSS-Cd was developed through a review of available technical information on cadmium alternatives, as well as discussions with several commercial industry representatives involved with cadmium use and substitution. The system is broken down into a series of tables to help the user identify materials which may be appropriate for their application. The tables include:

Table 1:	Suitable Materials for Army Applications
Table 2:	Material Properties Required for Army Applications
Table 3:	Material Performance in Material Property Categories

Suitable Materials for Army Applications

Table 1 of the AMSS-Cd is titled "Suitable Materials for Army Applications". This table lists the various material families used as cadmium alternatives. It indicates if they are appropriate for use in different major application areas where the U.S. Army still uses cadmium plating. The major alternative material systems are identified along with the major applications identified for the Army's use of cadmium plating. Table 1 has been included in the AMSS-Cd to help the user narrow down the list of all potential alternate material systems to just the material families that apply for the specific application of interest. Table 1 of the AMSS-Cd is included as Table 1 of this document.

Material Properties Required for Army Applications

Table 2 of the AMSS-Cd is titled "Material Properties Required for Army Applications". It lists the major Army applications of cadmium plating along with the key material properties that have been identified for the different types of cadmium applications. The list is meant to address performance requirements by most, but not all individual applications of cadmium within the category. Table 2 has been included in the AMSS-Cd to help the user narrow down the list of all potential material properties to just those that generally apply for the specific application of interest. If specific details are available for the application requirements, the information should be used to expand or further narrow the list of important properties for consideration when selecting an alternate material system. AMSS-Cd Table 2 is included as Table 2 of this document.

Material Performance in Material Property Categories

Table 3 of the AMSS-Cd is titled Material Performance in "Material Property Categories". It lists 1-10 ratings (10 being good, 1 being bad) for the alternate material systems in the key material properties that have been identified for different cadmium applications. The 1-10 ratings are described in the AMSS-Cd explanation report attached to the system. ***Table 3 is the heart of the AMSS-Cd.*** The information summarized in this table is used to select an alternative material system. Tables 1 and 2 are supplemental information that can be used to narrow down the fields of materials and properties prior to examining the performance ratings in Table 3. Sample material and property ratings from Table 3 of the AMSS-Cd are included as Table 3 of this document.

The ratings given in Table 3 are based on test data or application experience from several difference reference articles and many different types of test procedures. Whenever possible, information was used from the same test procedures to develop ratings for the same property category. This was not always possible. As an example, corrosion resistance combines data from different natural exposures, ASTM B117 salt fog testing, and other accelerated corrosion tests to allow for comparisons between some of the alternatives.

If specific data was not available for different material system thickness and surface finish combinations, it was inferred from data available for other combinations from the same material type. In some cases data was not readily available for an entire material family for a specific material property. In this situation the rating was inferred from information available from similar types of material families for the property of interest. These ratings are underlined in the AMSS-Cd and the sample of Table 3 given in this report.

Table 3 provides ratings for all of the different thicknesses and surfaces finishes described in the referenced specification. When possible ASTM standards are referenced. ***Other commercial and industry specifications can be used for these material systems.*** Different thickness and surface finish requirements can also be specified when appropriate. ***The thickness and surface finishes listed correspond only to those listed in the referenced standards and are not meant to restrict the AMSS-Cd user to these requirements.*** Additional information on other specifications is given in the explanation report for the AMSS-Cd.

Selection of an Alternate Material with the AMSS-Cd

Listed below are two examples of methods for using the ratings contained in Table 3 to help select an appropriate alternative material. The AMSS-Cd user could use either method, both in combination, or develop a customized analysis system to identify appropriate alternatives. (These two methods are only examples of possible user interaction with the system. Each user of the AMSS should develop their own system to identify an appropriate alternative.)

In the weight multiplication factor (WMF) example, the user creates a customized table of materials and performance ratings for their own application. Each performance property rating is then given its own weight factor, as determined by the importance of the properties for the function of the application. The sum of the products of the performance ratings and their WMFs for each possible material are then compared for each material. Material systems with the highest totals are then examined according to specific details for each performance or other key property category (non-performance properties such as cost) to determine the most appropriate substitute. This technique has the advantage of being quicker, and easier to customize for the relative importance of performance differences of different key property categories. The disadvantage of this method is that it treats a unit difference in rated performance as an equivalent difference within each property. For example, the difference in lubricity between ratings of 9 and 10 is 0.10, but the difference in lubricity for ratings of 5 and 6 is 0.20.

The Minimum Rating Requirement (MRR) technique requires the user to give attention to each material rating value for each key property of their application. The process will be time consuming but does allow the user to develop an understanding of the general strengths and/or weaknesses for the different alternatives for each key property they evaluate. The process includes narrowing of the total list of alternates by: (1) identifying both the appropriate materials for an application (Table 1) and the key properties for that application (Table 2); (2) prioritizing the key properties by importance; and (3) assigning minimum ratings and analyzing results for each key property listed in Table 2.

Efforts Performed to Update the AMSS-Cd

The original version of the AMSS-Cd was created from available physical and performance data. Some areas were found where information is unavailable. TACOM-TARDEC has sponsored three projects over the past year to update the AMSS-Cd where information is needed. These efforts included (1) evaluating cadmium replacements for electrical connectors, (2) evaluating cadmium alternatives for fastener applications, and (3) testing of possible chromate conversion coating replacements to enhance the performance of cadmium alternatives. Information gained from these programs added more in depth information to the applications sections of the AMSS-Cd. This information also reinforced and updated previous knowledge contained in the working document.

Cadmium Replacement in Electrical Connectors

Cadmium coatings have been used on military electrical connectors because they are compatible with the aluminum and steel materials that make up the connector and mating part bodies and do not form voluminous corrosion product that can interfere with delicate electrical contact surfaces. Electrical connector replacement is difficult due to a lack of knowledge for how newer material systems will perform for various connector applications. Therefore, an ongoing evaluation of alternative electrical connector backshell coatings is being performed. The data collected in this program will be incorporated into the AMSS-Cd upon project completion.

Potential alternatives tested included IVD aluminum, zinc/nickel, tin/zinc and Electroless nickel coatings on aluminum and steel backshells. These coatings have shown promise as alternatives based on testing conducted to eliminate cadmium from other areas. (More exotic alternatives exist, including gold or silver-based coating systems, but their application in electrical systems is typically reserved for contact surfaces rather than connector bodies.) Accelerated and natural exposure tests were used to evaluate the performance of the alternatives. Key properties including corrosion resistance, electrical conductivity, and durability were evaluated during testing.

Cadmium Alternatives for Fastener Applications

Cadmium has been used in fastener applications because of its corrosion protection properties and its attractive lubricity effects. Ion Vapor Deposited (IVD) aluminum coated fasteners with a chromate conversion coating (CCC) have shown comparable properties when dry film lubricants are applied. These fasteners plated with IVD aluminum with a CCC have shown corrosion resistance in testing, but they have been susceptible to environmentally assisted cracking (EAC). The addition of the dry film lubricants alleviated this problem in many of the tested samples.

Three dry film lubricant chemistries were tested: molybdenum disulfide, Teflon/PFTE, and calcium sulfonate. They were tested for torque-tension properties, corrosion resistance (atmospheric exposure, EAC), and breaking torque. The results have been incorporated into the AMSS-Cd and will be available when Version 2 is released.

Non-Chromate Sealers as Replacements to CCC to Enhance the Performance of Cadmium Alternatives

CCC(s) per MIL-C-5541 are the most widely used products for use as sealers on cadmium, zinc, zinc alloy, and aluminum surfaces. They are used for added corrosion protection and enhancing the adhesion of paint coatings to the base metal. CCC baths contain hexavalent chrome, a known carcinogen, that requires special wastewater treatment steps that increase the total amount of hazardous waste generated by a facility.

In this program, non-chrome sealers were identified through a literature search and evaluated for initial corrosion resistance properties on pure zinc plated steel components. Further testing was then done for replacement of the CCC on zinc alloy plating. The most promising sealers were tested over the alloys for natural and accelerated exposure testing and paint adhesion (applied through typical industry procedures). These results were compared with testing run upon the same alloys with different types of CCC. The data collected in this program will be incorporated into the AMSS-Cd upon project completion.

Acknowledgments

The authors would like to thank the Army Materiel Command's Army Acquisition Pollution Prevention Support Office (AMC-AAPPSO) for support in the development of the AMSS-Cd and its explanation report. The authors would also like to thank the many industrial and DoD representatives who were kind enough to review the draft version of the AMSS-Cd.

References

1. Ocean City Research Corporation Final Report, "Alternate Material Selection System for Cadmium (AMSS-Cd) Version 1", prepared for U.S. Army Tank-Automotive and Armaments Command, April 1997.

2. Ocean City Research Corporation Final Report, "Details of the Alternate Material Selection System for Cadmium", prepared for U.S. Army Tank-Automotive and Armaments Command, April 1997.

3. Ocean City Research Corporation Final Report, "Guidance for Eliminating Cadmium From U.S. Army Weapon Systems", prepared for Army Material Command, Army Acquisition Pollution Prevention Support Office (AMC-AAPPSO), April 1996.

4. Ocean City Research Corporation Final Report, "Evaluation of the Performance of Lubricious Topcoats on IVD Aluminum Coated Fasteners", prepared for Army Material Command, Army Acquisition Pollution Prevention Support Office (AMC-AAPPSO), February, 1998.

Table 1: Suitable Materials for Army Applications

Alternative Category	Sub-Category Description	Major Category	Fasteners	Fasteners	Small Steel Hardware	Small Steel Hardware	Electrical Connectors	Electrical Connectors
		Description	less than 150 ksi ultimate tensile strength	greater than 150 ksi ultimate tensile strength	Simple	Complex		
		Substrate	steel	steel	steel	steel	steel	aluminum
ALTERNATE COATINGS								
Zinc	Plating		Yes	Possibly, but Hydrogen Embrittlement and/or Environmentally Assisted Cracking (HE/EAC) possible	Yes	Yes	No	No
	Hot-Dip		Check Tolerances	Possibly, Check tolerances, EAC possible	Possibly	Possibly	No	No
	Inorganic		No	No	Possibly	No	No	No
Zinc Alloy	Sn/Zn		Yes	Yes	Yes	Yes	Possibly	Possibly
	Zn/Ni		Yes	Possibly, HE/EAC possible	Yes	Yes	Possibly	Possibly
	Zn/Co		Yes	Possibly, HE/EAC possible	Yes	Yes	No	No
	Zn/Fe		Yes	Possibly, HE/EAC possible	Yes	Yes	No	No
Aluminum	IVD		Possibly, galling possible at high stress	Possibly, galling possible at high stress	Yes	No	Possibly	Possibly
	Electroplate		Possibly, galling possible at high stress	Possibly, galling possible at high stress	Yes	Yes	Possibly	Possibly
	Al-ceramic		Possibly, Check tolerances, use lubricant	Possibly, Check tolerances, use lubricant	Yes	No	Possibly	Possibly
Paints	organic		No	No	Possibly	Possibly	No	No
	metal-filled		No	No	Possibly	Possibly	No	No
	Duplex		Possibly	Possibly	Possibly	Possibly	No	No
Barrier-Only Metal Plating	Tin		No	No	No	No	No	Possibly
	Nickel		Possibly	Possibly	Possibly	Possibly	Possibly	Possibly
	Gold, Silver, and alloys		No	No	No	No	No	Possibly
ALTERNATE BASE MATERIALS								
Stainless Steels			Yes	No	Yes	Yes	Yes	Yes
Composite with electroless nickel			No	No	No	No	Possibly	Possibly

Table 2: Material Properties Required for Army Applications

Major Application Category	Sub-Category	Substrates Material	Corrosion Resistance (1)	Material Compatibility with Aluminum	Lubricity	Hydrogen Embrittlement (HE)	Environ-mentally Assisted Cracking (EAC)	Fatigue Resistance	Wear (2)	Adhesion (2)	Low Contact Resistance	Solderability	Low Cost	Availability	Environmental Friendliness
Fasteners	Less than 150 ksi	steel	Yes	Possibly	Yes	No	No	Possibly	Possibly	Yes	No	No	Yes	Yes	Yes
	Greater than 150 ksi - Grade 8 min.	Steel	Yes	Possibly	Yes	Yes	Yes	Yes	Possibly	Yes	No	No	Yes	Yes	Yes
Small steel hardware		steel	Yes	Possibly	No	Possibly	Possibly	Possibly	Possibly	Yes	No	No	Yes	Yes	Yes
Electrical Connectors		steel	Yes	Possibly	Possibly	No	No	No	Possibly	Yes	No	Possibly	Possibly	Yes	Yes
		aluminum	Yes	Possibly	Possibly	No	No	No	Possibly	Yes	Yes	Possibly	Possibly	Yes	Yes

(1) Cadmium is used as a corrosion resistant coating. The amount of corrosion resistance required will depend on the environment the material will be exposed.

(2) This property is not typically a primary concern for cadmium applications, but it may become an issue when significantly different types of materials are substituted for cadmium (i.e. organics).

Table 3: Material Performance in Material Property Categories

ID #	Alternative Category	Sub-Category Description	Specification	Class or Grade	Type	Minimum Thickness (mils)	Finish	Substrates Used On (s=steel, a=aluminum, ss=stainless, t=titanium)	Corrosion Resistance (1)	Material Compatibility to Aluminum	Lubricity (dry)
1	Cadmium	Electroplating	QQ-P-416	1	I	0.5	as-plated	s, a	7	8	9
2				1	II	0.5	chromated	s, a	9	8	9
3				1	III	0.5	phosphated	s, a	8	8	9
4				2	I	0.3	as-plated	s, a	6	8	9
5				2	II	0.3	chromated	s, a	8	8	9
6				2	III	0.3	phosphated	s, a	7	8	9
7				3	I	0.2	as-plated	s, a	5	8	9
8				3	II	0.2	chromated	s, a	7	8	9
9				3	III	0.2	phosphated	s, a	6	8	9
10	Zinc	Electroplating	ASTM B633	Fe/Zn 25	I	1	as-plated	s, a	6	6	2
11					II	1	colored chromate	s, a	8	6	2
12					III	1	colorless chromate	s, a	7	6	2
13					IV	1	phosphate	s, a	7	6	2
14				Fe/Zn 12	I	0.5	as-plated	s, a	5	6	8
15					II	0.5	colored chromate	s, a	7	6	8
16					III	0.5	colorless chromate	s, a	6	6	8
17					IV	0.5	phosphate	s, a	6	6	8
18				Fe/Zn 8	I	0.3	as-plated	s, a	4	6	8
19					II	0.3	colored chromate	s, a	6	6	8
20					III	0.3	colorless chromate	s, a	5	6	8
21					IV	0.3	phosphate	s, a	5	6	8
22				Fe/Zn 5	I	0.2	as-plated	s, a	4	6	8
23					II	0.2	colored chromate	s, a	4	6	8
24					III	0.2	colorless chromate	s, a	4	6	8
25					IV	0.2	phosphate	s, a	4	6	8
26		Hot-Dip	ASTM A153			1.7		s	9	6	2
27		Inorganic				2		s	9	6	2
28	Zinc Alloy	Sn/Zn	BAC 5899	1	I	0.5	as-plated	s, a, ss, t	7	8	7
29					II	0.5	chromate treated	s, a, ss, t	8	8	7
30				2	I	0.3	as-plated	s, a, ss, t	6	8	7
31					II	0.3	chromate treated	s, a, ss, t	7	8	7
32				3	I	0.2	as-plated	s, a, ss, t	5	8	7
33					II	0.2	chromate treated	s, a, ss, t	6	8	7
34		Zn/Ni	ASTM B841	1	A	0.2	colorless chromate	s, a	5	7	8
35					B	0.2	yellow chromate	s, a	6	7	8

"Closed Loop" Re-refined Oil Program

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Defense Supply Center Richmond (DSCR) has taken another step towards accomplishing its mission of giving the customer "What it wants, when it wants it, and at the best value." This progressive new program called Closed-Loop involves re-refined oil with an added value -- When the customer orders re-refined oil from DSCR, they will have pick-up of their used oil included as part of the service provided by our contractor. This is a great benefit to the customers who now have to deal with cumbersome disposal contracts, contract administration, delinquent contractors, environmental concerns surrounding disposals, and additional costs for disposal of used oil. In many instances, customers are paying for disposal of their used oil. A Closed-Loop program helps the customers, as it will stop them from having to pay twice - once for buying re-refined oil and again for disposing of it.

Here's how the program works:

--No application is necessary to join the program; simply submit your requisitions to DSCR using MILSTRIP/FEDSTRIP requisitions with the NSNs listed below. You may also submit your orders by calling 800-345-6333 or fax them to 800-352-3291.

--Minimum orders apply (see below).

--Delivery time is seven days after the receipt of your order.

--Three types of oil are offered (see next page):

Closed Loop Re-refined NSNs

10W-30 iaw CID A-A-52039

9150-01-438-5875	10W-30	1 qt plastic	BX	$ 10.69
9150-01-438-5882	10W-30	5 gal container	CO	$ 16.22
9150-01-438-5891	10W-30	55 gal drum	DR	$147.62
9150-01-438-5933	10W-30	Bulk	GL	$ 2.31

15W-40 iaw CID A-A-52306

9150-01-438-5905	15W-40	1 qt plastic	BX	$ 10.36
9150-01-438-6064	15W-40	5 gal container	CO	$ 16.22
9150-01-438-6066	15W-40	55 gal drum	DR	$150.36
9150-01-438-6071	15W-40	Bulk	GL	$ 2.36

15W-40 iaw Military Specification MIL-L-2104

9150-01-438-6076	15W-40	1 qt plastic	QT	$ 1.02
9150-01-438-6082	15W-40	5 gal can	CN	$ 15.30
9150-01-438-6079	15W-40	55 gal drum	DR	$160.62
9150-01-438-6084	15W-40	Bulk	GL	$ 2.51

MINIMUMS

120 QT	4 CO	1 DR
10 BX	4 CN	200 GL

BX = 12 Quarts, CO and CN = 5 Gallons

Pick up of used oil is included in the NSN price of the oil:

--Your used oil will be picked up within 72 hours of your call to Safety-Kleen, the program's contractor, at 1-800-525-5739.

--Minimum pick up quantity is 55 gallons.

--Maximum pick up quantity is defined as 120 percent of the amount ordered.

Pick up of used oil, continued:

--The used oil may be mixed as long as the contents are petroleum based. What can be included in the mixture of used oil?

Most industrial oils are acceptable.

Automatic rejects include the following:

Ethylene/Polyethylene	Antifreeze
Resin/Varnish	Inks
Highly aromatic oils/solvents	Oils high in chlorine
Water-soluble compounds	Animal fats
Fatty acids	Transformer oils
Oily sludge	Oil high in ash
Oils mixed with hazardous wastes	Rolling oils
Water content greater that 15 percent	

--Two tests are conducted at the time of pick up: flash test and chlor-detect test. As with private industry, installations are responsible for direct charges from Safety-Kleen for contaminated or high water content loads.

What are the benefits of using the Closed Loop Program?

The DSCR "Closed-Loop" program does away with the need for separate contracts for disposing of used oil and with the hassle of administering such contracts, take environmental burdens off the customer, and save the customer money.

Another added advantage to this program will be the introduction of bulk deliveries in addition to the already established packaged offerings. This gives the customer more options in support of their missions.

You are assured that your used oil is being recycled:

Also, it is important to note that this program specifies that the used oil will go to a re-refiner for re-refining, vice to a burner. Although some bases currently "sell" their used oil to burners or simply burn in their own facilities, this is not considered recycling. Executive Order 12873 specifies that "the Nation's interest is served when the Federal Government can make more efficient use of natural resources by maximizing recycling and preventing waste wherever possible." Burning used oil is not maximizing recycling and preventing waste because once oil is burned, it can no longer be used again. On the other hand, re-refining oil presents an indefinite recycling loop and therefore maximizes recycling of this precious product. It does this in two ways. First, the base stock oil is refined back to its original status and can be used again and again.

Secondly, the "bottoms" removed during this refining process can be used in asphalt blends. Every effort is made to maximize recycling during the re-refining process.

What is the quality of the re-refined oil?

Oils offered in the program are made form 100 percent re-refined base stock and meet the American petroleum Institute's SJ and energy conserving performance classification for 10W30, and SJ/CF, CF-4, CF-4 performance classification for 15W40 A-A- 52306 oils.

The U.S Army Tank-Automotive and Armaments Command has reviewed and approved the Safety-Kleen re-refined oil as meeting the requirements of commercial item descriptions A-A-52039 and A-A-52308. The Safety-Kleen re-refined oil has also been qualified by that command for listing on the Qualified Products List for MIL-L-2104.

These manufacturers endorse re-refined oil for use in their engines: Chrysler Corporation, Ford Motor Company, General Motors, Caterpillar, Cummins engine Company, and Detroit Diesel. Position papers are available upon request.

The United States Postal Service and the National Park Service already participate in a closed-loop program with private industry and the USPS won the prestigious White House Closing the Circle Award for its use last year. We are confident our program will present all Federal activities with an opportunity to satisfy many motor oil related concerns.

POC for the Closed-Loop Program is Mrs. Kim Holland at DSCR: email kholland@dscr.dla.mil or phone (804) 279-3855/DSN 695-3855.

Replacement of P-D-680 Solvents

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Background

Army and other Department of Defense (DoD) facilities have been and continue to experience problems using P-D-680, Dry cleaning and Degreasing solvent[1], for their maintenance activities. Currently, numerous federal, state, and local regulations impact usage of P-D-680 as a hazardous waste, a flammable material, a toxic substance, and an air pollutant[2]. To resolve this problem, each of the services has initiated efforts to minimize P-D-680 solvent usage and to replace P-D-680 solvents with environmentally acceptable materials that are less hazardous and have effective cleaning performance. Under the auspices of the Joint Services Working Group (JSWG) on Minimization of Petroleum Distillate Solvents for Military Applications, the Fuels and Lubricants Technology Team of the Tank-Automotive and Armaments Research, Development, and Engineering Center (TARDOC) as the specification preparing activity for P-D-680 has been working to develop environmentally compliant alternatives to P-D-680 that would be able to meet military requirements. This program, resourced under the Defense Supply Center Richmond's (DSCR's) HAZMIN Program, was divided into the following two Phases.

Phase I: Conduct user surveys for P-D-680 solvents and evaluate commercial alternative solvents

Phase II: Conduct field validation tests, and revise the P-D-680 specification

(a) Army and Air Force Applications
(b) Navy Aviation and Shipboard Applications

All tasks of these Phases have been completed, and the test results and findings were summarized in this paper.

P-D-680 User Survey

The objectives of P-D-680 user survey were to determine what is viewed to be requirements for P-D-680 solvents, the positive and negative aspects of current solvents, and the characteristics of an "ideal" solvent replacement. Total fifty-four (54) responses were received from various installations operated by Army, Navy, Air Force, Marine Corps, National Guard, and NATO. Most users reported that P-D-680 solvents are excellent degreasers, have good corrosion protection properties, and are currently used for degreasing machine parts in equipment maintenance including helicopters. Twenty-five (25) percent use Type I, sixty-three (63) percent use Type II, and twelve (12) percent use Type III. The survey also indicated that Types I and II solvents do not meet the numerous federal, state and local environmental regulations due to their

high VOCs and low flash points. In conjunction with replacement of P-D-680 solvents, most users did not want to substitute other types except for petroleum based solvents in their applications due to the rusting, freezing and compatibility problems. Concerning the quality control of P-D-680 solvents, most users expressed negative responses in having a Quality Product List (QPL) for P-D-680 solvents because off-the-shelf products are more readily available. However, they want to have some quality control on P-D-680 solvents for safety. In this survey, P-D-680 users also expressed their own opinions on the requirements and constraints for an ideal P-D-680 solvent that can be used in their applications. These are summarized as follow:

- Effective clean and fast drying
- Low VOCs
- Low toxicity and low odor
- Low flammability (high flash point)
- Recyclable or biodegradable
- Material compatible
- Cost effective
- Corrosion protection

Laboratory Evaluation

Currently, numerous different types of cleaners/solvents are formulated for use in various of applications and are available in domestic markets. For the study, eighty-two (82) samples were evaluated and compared to P-D-680 solvents. These samples were originally solicited for evaluation as potential substitutes of P-D-680 solvents. Most solvents are currently used for general maintenance parts cleaning and were formulated with various chemical materials classified as aqueous, semi-aqueous, terpene and petroleum. To assess their physical and chemical properties, all samples were tested according to an established testing protocol. To provide baseline comparison data, P-D-680 solvents were also evaluated. The laboratory test results of candidate solvents were reported at the TARDEC technical report[3] entitled "Replacement of P-D-680 Solvents for General Maintenance of DoD Equipment". Based on the laboratory tests, it revealed that only petroleum distilled hydrocarbon solvents and terpene/hydrocarbon solvents meet current P-D-680 performance requirements that reflect military needs. Especially, terpene/hydrocarbon blended solvents showed excellent performance in all requirements. These products are listed under the proposed Type IV. Unlike these solvents, aqueous types of solvents and water-based solvents do not lend themselves as candidate P-D-680 solvents due to their poor corrosion protection and solvency.

Initially, twenty-three (23) commercial solvents were found for candidate alternative P-D-680 solvents. Then, the typical eight (8) candidate solvents were selected for the next Phase study. These products provide excellent solvency, are currently listed as less hazardous solvents, and meet the federal and local environmental laws (i.e., RCRA). Table 1 lists the physical/chemical properties of typical eight (8) candidate solvents that were found in the laboratory evaluation.

Field Demonstration

In concert with the Phase II portion of this initiatives, the field demonstrations were conducted at

DoD installations to verify performance and environmental applicability of candidate solvents under a variety of field environments.[4,5] Table 2 summarizes field testing sites and solvents that were evaluated at each installation as well as identifying the cleaning procedure used and equipment. The major evaluation criteria used in this demonstration were odor, cleaning power, residue, corrosion protection and toxicity.

Fort Lewis evaluated seven (7) candidate solvents (Breakthrough, Unocal 150, Actrel 1171L, 134 Hi-solv, Skysol 100, PF, and Electron 296) in tactical vehicle maintenance shops and compared with P-D-680. The test results showed although the new solvents provided somewhat weaker solvency than P-D-680, they demonstrated good cleaning ability in a wide variety of soils, especially heavily contaminated grease, hydraulic fluid, engine oils, tar, carbon deposits and waxes. Most users reported the solvency of the terpene/hydrocarbon blended solvents was the same as the other types of candidate hydrocarbon solvents. All solvents tested in ground equipment provided adequate solvent power. No corrosion, residue and compatibility problems were reported. Two hydrocarbon solvents (Unocal 150, Actrel 1171L) were rejected due to their strong offensive odor, which may affect worker's health. However, citron odor was not a problem in the ground vehicle cleaning applications.

In aviation applications, Fort Lewis helicopter maintenance shop also evaluated Skysol 100 solvent using helicopter parts such as engines, rotors, and generators. etc. This shop is currently seeking a new environmentally complaint solvent in order to replace P-D-680 Type I which defined as a hazardous material due to its low flash point. The test results showed that the solvency of Skytel 100 solvent was adequate to clean soils contaminated in various types of aviation parts. No corrosion and compatibility problems were reported. Citron odor was not a major problem. However, some complaints related to slow drying time were received. Generally, Type II solvents provide slower drying time than Type I due to their higher flash points. This deficiency is minor and can be resolved using air dryers or ovens. Currently, Type II solvent is strongly recommended to replace the Type I as a means to reduce flammability problems.

P-D-680 solvents are also widely used in weapon cleaning applications. To verify the performance of candidate solvents in weapon applications, Fort Lewis evaluated three solvents (Breakthrough, Skysol, Skysol 100) using small arms such as the M16 rifle. The test results showed the performance of all candidate solvents was acceptable except for their odor characteristics. In these demonstrations, a strong citron odor was a major problem in closed areas of weapon cleaning facilities. Generally, the large variations of odor depend on human sensitivity and are very difficult to control in small closed area. Odorless products such as Breakthrough solvent were well accepted in both open and closed weapon cleaning facilities.

Ft. Hood also evaluated two (2) candidate solvents (Skysol 100, Breakthrough) in helicopter maintenance applications and weapon cleaning applications. Both solvents were very well accepted in all maintenance applications. Especially, most users indicated candidate solvents significantly reduce the toxicity (i.e., skin irritation) when compared to P-D-680. Drying time of candidate solvents was the same as for P-D-680 Type II.

San Antonio Logistic Center at Kelly AFB evaluated three (3) candidate solvents (Breakthrough, Actrel 117L, and Electron 296). In aviation fuel injection repair shop, Breakthrough solvent was very well accepted in comparison to the Actrel 1171L solvent due to its odorless characteristics. Electron

296 solvent was also well accepted by aviation ground supporting equipment such as electric generators, No d-limon odor problem were reported.

Naval Surface Warfare Center (NSWC), Carderock Division, MD evaluated Breakthrough solvent using cartridge-type deep groove bearings coated with DOD-G-24508, Grease, High Performance, Multipurpose. For comparison purpose, a P-D-680 Type II solvent was also reevaluated using the same bearing cleaning procedure. The test results showed that Breakthrough solvent is superior to P-D-680 Type II in cleaning shipboard bearings lubricated DOD-G-24508 grease. It was noted that P-D-680 solvent had a longer drying time, left a residue, and did not break-down the grease as quickly as the candidate solvent.

The Shore Intermediate Maintenance Agent (SIMA) of Naval Station, Mayport, FL also evaluated Breakthrough solvent using shipboard engine and missile components. This shop currently uses P-D-680 Type I as a regular cleaning agent. Based on the SIMA field demonstration, it was reported that the Breakthrough is acceptable solvent for the replacement of P-D-680 Type I in their shipboard applications because of its odorless characteristics and good cleaning performance.

Naval Air Warfare Center (NAWC), Patuxent River, MD also evaluated Breakthrough solvent in various aircraft supporting equipment such as compressor valve, bearings, intake oil breathers, etc. In a similar result, the Breakthrough solvent was accepted to clean soils from various types of aviation parts. No corrosion and compatibility problems were reported.

Naval Aviation Depot (NADEP), Cherry point, NC evaluated four (4) candidate solvents (Breakthrough, Electron 296, PF, 134 Hi-Solv) in various aviation and ground equipment (i.e., cargo aircraft, utility vehicles). All candidate solvents were well accepted as the replacement of P-D-680 solvents.

Solvent recycling is common practice in many industries and wide range of solvents are currently recycled using distillation techniques or filtration. Although a solvent recycling demonstration was not conducted in this study, most users observed that the recirculation parts washer actually served as a recycling unit and significantly extended solvent useful life.

Toxicity Clearance for Candidate Solvents

All candidate products are non-carcinogenic and do not contain any ingredients listed by EPCRA, CERCLA, and RCRA. Also, worker exposure is not regulated by OSHA. However, there is a new requirement for all new products entering the military supply system in that each is to be reviewed and given Toxicity Clearance by the Center for Health Promotion and Preventative Medicine (CHPPM). As a part of this program, CHPPM approved the toxicity clearance for six (6) candidate solvents that were accepted.

Conclusions

On the basis of the work completed to date, the following Table lists environmentally compliant solvents that were found as acceptable replacements for P-D-680 solvents. Based on the DoD field demonstration, P-D-680 specification is being revised to accept new environmentally complaint solvents.

Type	Solvent composition	Candidate P-D-680 solvent
I	Hydrocarbon	Type II solvent
II	Hydrocarbon	Breakthrough
III	Hydrocarbon	134 Hi-Solv Current Type III solvent
IV*	Terpene/Hydrocarbon Blend	Electron 295, PF Skysol, Skysol 100

* This is a proposed new Type for P-D-680 and its performance is equivalent to Type II.

Also, the following findings evolved during this study.

- Severe hydrotreated odorless hydrocarbon solvents were very well accepted because their low odor characteristics and less toxicity.

- Hydrotreated terpene/hydrocarbon blended solvents were also very well accepted in all DoD applications. Citron odor was not considered as a major problem in open working area.

- Odor, cleaning power, corrosion protection and toxicity of solvent were major evaluation factors for all cleaning applications.

- P-D-680 Type II solvent had a long drying time, strong offensive odor, left residue, and did not break-down the grease as quickly as the candidate solvent. For these reason, most participants rejected the use of P-D-680 Type I and II solvents in their cleaning applicants.

- Low odor hydrotreated Type II hydrocarbon solvent was acceptable for weapon cleaning applications due to its odorless characteristics.

- All candidate solvents performed well for all applications when compared to P-D-680 solvent.

- Candidate Type II solvents were found to be acceptable when used in applications requiring Type I.

References

1. Federal Specification P-D-680, Dry Cleaning and Degreasing Solvent, 29 October, 1992.
2. Connie Van Brocklin, "Replacement of P-D-680 for Army Ground Vehicle and Equipment Applications", Letter report 94-1, October, 1993.
3. In-Sik Rhee, Carlos Venez, Karen Von Bernewitz, "Replacement of P-D-680 Solvents for General Maintenance of DoD Equipment", TARDEC Technical Report No. 13643, September, 1995.
4. In-Sik Rhee, Carlos Venez, "Field Demonstration for P-D-680 Solvent Replacement", TARDEC Technical Report No. TR-13730, October, 1996.
5. In-Sik Rhee, "Field Demonstration for P-D-680 Solvent Replacement (Part II)", TARDEC Technical Report No. TR-13751, May, 1998.

Table 1. Laboratory Solvent Test Results

Product Code	Flash Point °C	Distillation, °C		Kauri-Butanol value	Non-volatile residue, %	Aniline Point, °C	Odor	VOC g/l	Evap, %, @20 min	Corrosion		Relative Solvency, %
		I.B.P	D.P							Cu	Fe	
P-D-680 (1)	47.0	165.4	204.6	39	0.1	61.2	strong	789.7	47.1	1a	no rust	94.7
P-D-680 (II)	63.0	182.8	206.7	32	0.07	73.1	strong	785.8	22.8	1a	no rust	94.4
P-D680 (III)	93.3	223.4	269.0	31	0.3	76.1	odorless	823.2	4.6	1a	no rust	89.3
Breakthrough	65.5	184.0	211.7	27	0.05	84.0	odorless	770	25.9	1b	no rust	87.6
Actrel 1171L	81.1	211.6	241.1	30	0.35	77.8	strong	797	10.1	1a	no rust	84.5
Unocal 150	66.7	186.0	212.7	31	0.15	71.2	mild	772	19.1	1b	no rust	90.2
134Hi-Solv	97.8	232.4	299.3	24	0.07	94.5	odorless	796	3.8	1b	no rust	80.7
Skysol	66.7	189.4	212.4	29	0.16	83.0	citrus	770	20.0	1b	no rust	89.1
Skysol 100	63.3	189.6	212.7	29	0.44	82.8	citrus	780	25.3	1a	no rust	88.6
Electron 296	63.9	191.8	235.6	32	0.01	69.1	citrus	782	18.1	1b	no rust	87.8
PF	62.2	187.0	228.8	26	0.32	76.7	citrus	760	14.8	1b	no rust	92.3

Table 2. Field Testing Sites for P-D-680 Replacement Solvents

Military Installation	Candidate Solvent	Testing Site	Military Equipment	Cleaning Method	Specified Solvent	POC
Ft. Lewis	Breakthrough, Actrel1171L, Unocal 150, 134 Hi-Solv,Skysol, Skysol 100, Electron 296, PF	18	Ground Equipment, Helicopter, Weapon system	Hand cleaning procedure using IT-30 parts washers	P-D-680 Types I and II	Ms. Cynthia K. Trout Tel: 206-967-3268
Ft. Hood	Breakthrough, Skysol 100	4	Helicopter, Weapon system, Small arms	Hand cleaning procedure using IT-48 parts washers	P-D-680 Type II	Mr. R.J. Holley Tel: 817-287-7145
Kelly Air Force Base	Breakthrough, Actrel 1171L, Electron 296	2	Aircraft, ground supporting equipment	Ultrasonic and Hand cleaning procedure using existing parts washers	P-D-680 Type II	Mr. Marlin Baggett Tel: 210-925-7391
NADEP, Cherry Point	Electron 296, 134 Hi-Solv, Breakthrough, PF	5	Aviation, ground supporting equipment	Spray buster and Hand cleaning procedure using parts washers	P-D-680 Types I and II	Ms. Jacki Grant Tel: 919-464-7164
NSWC, Carderock Division	Breakthrough, P-D-680 Type II	1	Shipboard groove bearings	Hand cleaning procedure using a parts washer	P-D-680 Type II	Ms. Mary L. Wenzel Tel: 301-227-5359
Naval Station, Mayport	Breakthrough	1	Shipboard engine and missile components	Hand cleaning procedure using a IT-48 parts washer	P-D-680 Type I	Mr. Bob Tierney Tel: 904-270-6730
NAWC, Patuxent River	Breakthrough	1	Aircraft supporting equipment	Hand cleaning procedure using a IT-30 parts washer	P-D-680 Type II	Mr. Don McLaurin Tel: 301-342-7989

Solvent Standardization Project: Weapons Cleaning Using Breakthrough and the IT48WC Parts Washer (#176)

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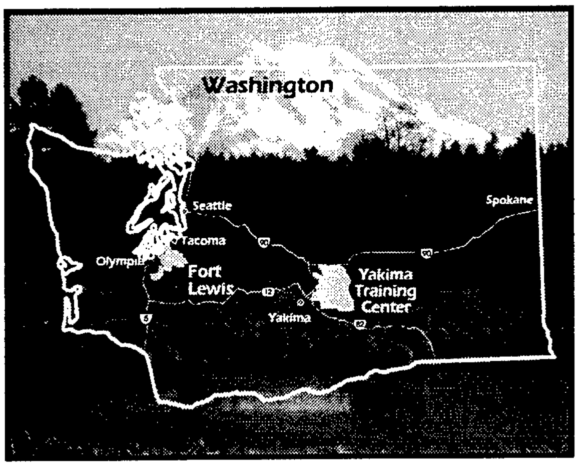

"The mission of Fort Lewis is "to train, mobilize, and deploy combat ready forces to fight and win worldwide; to care for soldiers, families, and our workforce; and to sustain a quality installation."

IDENTIFICATION

Fort Lewis Military Reservation is an 86,176 acre Army installation located 35 miles south of Seattle and 7 miles northeast of Olympia. Various military and non-military organizations at Fort Lewis perform services and functions that require the use of hazardous substances and generate hazardous waste. These activities are vital to the field readiness of military troops and support the day-to-day functions of Fort Lewis as a community. Services include the maintenance of over 4,500 Fort Lewis buildings and infrastructure such as roads and utilities, operation and maintenance of over 3,000 vehicles and nearly 1,500 pieces of equipment including aircraft, weapons systems, power generators, and communications equipment. A major hospital, several medical and dental clinics, printing and graphics facilities, materials storage warehouses and crafts shops also operate on Fort Lewis.

Fort Lewis, the largest employer in Pierce County, has a combined military, civilian and retiree payroll of almost $1 billion. Fort Lewis' force structure includes I Corps Headquarters, which commands all Forces Command units at Fort Lewis. I Corps Headquarters conducts planning and also acts as a liaison with other active and reserve component units in the continental United States and active duty units located around the Pacific Rim and in Hawaii. Fort Lewis directly supports the Yakima Training Center and six Base Realignment and Closure installations in Washington and California. The installation also serves occasional users from other U.S. armed services and units from allied nations.

PROGRAM OVERVIEW

The solvent standardization program is a major pollution prevention initiative designed to reduce the different types of solvent waste currently generated at Fort Lewis. This project reduces regulatory management and reporting burdens placed on the soldier by reducing the number of solvents authorized

for use. In addition, the regulatory reporting burdens for the Hazardous Waste Program, Pollution Prevention Program and the EPCRA Program are reduced.

This program was designed to target vehicle maintenance applications and weapons cleaning. The Safety Kleen contract is the preferred solvent source for parts cleaning in vehicle maintenance. Service schedules have been increased from 2-week cycles to 8 or 12 week cycles and all parts washers have filters. Implementation of this project resulted in a 64% reduction in waste generated from Safety Kleen solvent.

The weapons cleaning standardization project was driven from a health and safety aspect rather than from a waste reduction aspect. Cleaning weapons generated various waste streams that were being mismanaged. Various materials have historically been used to aid in the removal of carbon from weapons. These materials included, but were not limited to mixtures of diesel and pine oil, trichloroethylene and gasoline, oven cleaners, carbon removing compounds, and breakfree. The purpose of the weapons cleaning standardization project was to provide the tools and a standard solvent to aid in weapons cleaning.

TECHNIQUES AND INNOVATIONS

Prior to reassembly and storage, weapons require periodic cleaning to remove dirt, dirty lubricants, and carbon. A variety of materials had been used to clean weapons at Fort Lewis. The materials were often sprayed on and wiped off. This process was then repeated at least three times over a period of three days. Many of these materials were hazardous or contained ozone depleting substances. The absence of dedicated cleaning stations and the absence of spent weapons cleaner as a waste stream lead the environmental staff to fear that these hazardous materials may have been mismanaged or disposed of improperly.

To reduce the probability of improper waste disposal, reduce the amount of time required to clean weapons, reduce solvent use, and to identify a standardized, less regulated weapons cleaning solvent, a field demonstration was initiated. The Mobility Technology Center-Belvoir, Fuels and Lubricants Division, is the DOD Executive Agent for all Ground Fuels and lubricants and also manages the P-D-680 federal specifications. The field testing at Fort Lewis began in May 1996 and was a joint venture with Fort Belvoir, I Corps Science Advisor and Public Works Environmental and Natural Resources Division. Fort Lewis was the DOD field test site for Vehicle Maintenance and Small Arms Operations. The field tests assessed the performance and toxicity of eight candidate solvents used to clean weapons and vehicles. Solvent cleaning power, compatibility, drying time, corrosivity, the propensity to leave a residue, odor, and dermal toxicity were all rated for each of these eight candidate solvents, as well as for the current P-D-680 type I-II and type(III) solvents. To facilitate this evaluation, several tanks were purchased.

Between October, 1996 and March, 1997, the Fort Lewis Public Works - Environmental and Natural Resources Division (PW/ENRD) purchased, installed, and retained custody of 37 "IT-48WC" weapons cleaning stations from "Inland Technology". Thirty-two of these weapons cleaning stations were installed at Fort Lewis and five were installed at the Yakima Training Center. The IT-48WC station was selected because it was the only station that was designed for weapons cleaning at that time. However, we have identified significant design flaws.

In October of 1996 the tests concluded that "Breakthrough" was the best candidate and that it would be implemented as a pre-cleaning step in all weapons cleaning functions. Breakthrough (NSN #6850-01-378-066) consists of C-12 and C-13 paraffinic hydrocarbons (CAS # 54742-48-9). It is relatively odorless and has a low dermal toxicity. It has a flash point of 150• F, a vapor pressure of less than 2 mm Hg, and is 100 percent volatile.

The IT-48WC is designed so that two individuals can clean weapons simultaneously. It measures 48 inches wide and 28 inches from front to back. It is designed so that solvent from the bottom of the 55-gallon tank is pumped by a 15 gallons per minute (GPM) pump through a stainless steel filter and then through a 0.01 micron filter. (The actual flow rate appears to be significantly less than 15 GPM.) After

traveling through the filters the solvent passes through an 18 inch flex hose or through two clear lines and through two brushes (in parallel). The brushes are used to clean weapons. The dirty solvent is collected in a work tray before it runs through a 3.5-inch drain basket (which is designed to capture large debris) and is then recirculated through the system again.

During the summer of 1997, PW/ENRD, which has custody of the weapons cleaning stations, became concerned about the frequency with which the secondary filter needed to be changed. This is because the pre filter's porosity was too great for it to effectively remove any contaminants. The metal pre filter wouldn't capture any contaminants until it got clogged up and had to be taken out and wiped with a pad creating an extra waste stream. Subsequently all the contaminants were caught in the main filter. Changing filters takes about fifteen minutes per tank. It is also costly. Initially, the main filters cost $18 each. (They now cost $8.87.) Furthermore, if the filters clog and the pump is allowed to continue to run, the pump will burn out and require replacement. To increase the life of the main filter, the prefilter (a stainless steel screen) was first replaced with a 20-micron cotton filter to increase the effectiveness of the initial filtering process. This resulted in the pre filter becoming clogged very quickly necessitating frequent changes. The 20-micron cotton filter was therefore an unacceptable alternative. A resin filter (NSN #4250-01-381-8036) which ranged from 50 microns on the outside to 10 microns on the inside was then tested and found to be an acceptable replacement pre filter. We implemented these pre filters in all our weapons cleaning stations and now we get twice the life out of our main filters. These new pre filters cost $4.08 each.

To reduce the frequency of solvent replacement, PW/ENRD began testing on-site filtration (in addition to the two filters on each weapon cleaning station). On-site filtration consists of an outside vendor coming on-site to the tank itself, removing the solvent from the tank, cleaning the tank, changing the filters, filtering the solvent making three to six passes through their mobile filtration system and putting the solvent back into the tank. The tests were successful and PW/ENRD has incorporated this service into its standard operating procedure. This new filtering frequency is unknown and is contingent upon the contamination rate of the solvent (which is in turn dictated by the cleanliness of the part), but it is estimated that filtering is required about once every six months.

POLLUTION PREVENTION PROJECT BENEFITS

This project significantly reduces the probability of improper hazardous waste management and improper hazardous waste disposal. In the past, weapons were cleaned in a variety of locations, some of which were unknown. These dedicated cleaning stations ensure that solvents used for weapons cleaning are managed or disposed of properly. This project has also focused attention on proper waste management of solvent contaminated absorbent pads, rags, and other debris, and has significantly reduced the probability that this type of hazardous waste will be disposed of as non-hazardous waste.

This project also reduces the toxicity and environmental impact of solvents used and establishes a uniform solvent for weapons cleaning. Many of the weapons cleaning solvents contained substances that deplete upper atmospheric ozone and have been banned from production under the Montreal Protocol. Breakthrough does not contain any ozone depleting substances and is significantly less toxic than many of the weapons cleaning solvents previously used. Furthermore, the new solvent and weapons cleaning stations reduce the amount of time required to clean weapons by approximately 85 percent. This in turn has very large economic benefits.

Hazardous Waste Reductions: It is not possible to accurately calculate the hazardous waste reduction that results from this project. Much of the waste that was generated from weapons cleaning in the past was mismanaged (e.g., disposed of as non-hazardous solid waste). Therefore, there is no baseline data (i.e., we do not know how much hazardous waste was actually generated from weapons cleaning prior to the implementation of this project). Since we do not know how much hazardous waste was generated in the past, we cannot quantify the waste reduction. Through pollution prevention, this project served to improve compliance (by improving waste management).

Hazardous Material Use Reduction: The amount of hazardous material reduced as a result of this project is estimated at approximately 4,000 gallons per year. Breakthrough is the approved solvent for pre-cleaning the weapon prior to final detail. By providing an odor-less solvent in a large format parts washer, we reduce the frequency of exotic cleaners being used for removing carbon.

Economic Benefit: Because of the reductions in troop labor (85% reduction), this project had a payback period of 15 days. This project saves Fort Lewis almost $2.9 million per year (based on a project life of 10 years), and has a ten year net present worth of over $22 million. Implementation of this P2 project is therefore justified, and the cost savings are validated on an annual basis.

Life Cycle Analysis of Risk Shifting: This project reduces the toxicity of solvent used, reduces the probability that solvents will contaminate soil and surface waters, and reduces ozone depleting substance emissions. Furthermore, risk is not shifted from one process, product, or environmental medium to another. Therefore, there is a net reduction in risk to the environment.

LESSONS LEARNED

Fort Lewis has been very happy with Breakthrough, the new solvent that was implemented. At the time of implementation, these weapons cleaning stations were the only ones available in a large format. . However, the weapons cleaning stations have not been without problems. These problems include the following.

- The lids have a fusible link for fire protection. These links must be released prior to shutting the lid. Invariably, personnel attempt to shut the lid without releasing it. This causes the lids to bend and buckle. Eventually, the rivets attaching hinges to the lid loosen until hinges become inoperable. The hinges should be manufactured with bolted hinges instead of riveted hinges.

- The lids do not have a handle on them and they are difficult to open. The lids should be manufactured with handles.

- The filtering system in the cleaning station suffers from significant design flaws. The system consists of two filters in series. The filters are designed to clean the solvent and prolong its life. The first is a stainless steal mesh with a porosity that is too large to capture most of the contaminants. The second filter is a 0.01-micron filter that becomes clogged very easily. If a filter is not changed when it is plugged, the pump will burn out and require replacement. To reduce labor and costs associated with secondary filter replacement, the first filter has been changed from the stainless steel mesh to a resin filter that ranges from 50 microns on the outside to 10 microns on the inside (NSN #4250-01-381-8036).

- To prolong solvent life, Fort Lewis has begun to use an outside contractor to come on-site, remove the solvent from the tank, clean the tank, change the filters, filter the solvent on-site, and then put the solvent back into the tank. The frequency of this on-site filtering is expected to be once every six months.

- Too much solvent in the IT-48WC tank. There is less than one quart of solvent inside the filter canisters. There is also less than one quart of solvent actively being used on the surface of the parts being cleaned inside the tank. It is fair to say that the total volume of the active solvent is less than one half gallon. The 55-gallon solvent reserve in the IT-48WC is 100 times the volume of the active in-use solvent. We believe that the larger sink format of the IT-48 does not justify the huge increase in the size of the solvent reserve.

- To reduce the probability of solvent contamination, locks have been installed on weapons cleaning stations.

CONCLUSION

Breakthrough provides an odor free pre-cleaning step for weapons maintenance. The IT48WC provides a tool to clean the weapons safely and efficiently. The major cost savings from this project is due to reduction in troop labor.

Under the Pollution Prevention Act of 1990 and Washington State Waste Reduction Act (WAC 173-307) users of hazardous substances and generators of hazardous wastes are required to set goals to reduce usage of hazardous materials and generation of hazardous wastes. This pollution prevention initiative is a source reduction initiative (technology change, procedural change, and a product change). Breakthrough is a product substitute that is less toxic and less hazardous. The parts washers with the filtration system extend the life of the solvent thereby reducing the volume of product purchased and the volume of hazardous waste generated. A follow on pollution prevention initiative, the changing of the metal mesh filter to a resin filter reduces the volume of secondary filters used. Implementing the on-site filtration program extends the life of the solvent and reduces labor associated with management of the parts washer.

SESSION XXIV
SOLID WASTE REDUCTION/COMPOSTING

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POLLUTION PREVENTION AND SOLID WASTE MANAGEMENT AT VANDENBERG AIR FORCE BASE, CALIFORNIA

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Vandenberg AFB operates a Class III Sanitary Landfill (base landfill), and until recently, did not have management plans to effectively control waste acceptance from base personnel, contractors, and residents. To alleviate this situation, the 30th Space Wing at Vandenberg AFB has been aggressive in developing solid waste management programs that will reduce the amount of waste being disposed of in the base landfill, and that will emphasize pollution prevention through base-wide reuse, recovery and recycling. The 30th Civil Engineering Squadron Environmental Management Flight (30 CES/CEV), with the assistance of the Wing Environmental Services Contractor, Tetra Tech, Inc. (Tetra Tech), developed a Solid Waste Management Plan, accomplished a Green Waste Management Opportunity Assessment, and performed a Study for Increasing the Efficiency of Recycling Programs. This paper addresses the results of these important solid waste management documents and studies.

Solid Waste Management Plan (SWMP)

The Solid Waste Management Plan (SWMP) provides the framework of the solid waste management process at Vandenberg AFB, by establishing management roles and responsibilities, and reviewing the effectiveness of current solid waste methods and technologies in place: sanitary landfill, refuse collection, recycling programs, and a household hazardous waste program. The plan also provides an economic analysis of current disposal methods, and methods for implementation of the base-wide solid waste management process to address California and Air Force compliance directives and reduction goals.

As an overall base guidance document, the SWMP sets forth parameters to ensure that the base landfill will continue to operate in compliance with all federal, state, local, and Air Force requirements and remain a viable alternative for the management of future solid waste generation. The continued availability of a base landfill is essential to the future support of national space and missile programs; if waste disposal trends continued at current rates, the base

landfill would reach capacity in 2034, and alternative waste disposal sites, such as off-base landfills, would have to be considered.

To ensure that the base landfill remains a viable option for waste disposal through 2084, Vandenberg AFB must reduce and maintain waste disposal in the landfill by 24.7 percent per year from 1997 through 2000, the equivalent of reducing accepted waste by approximately 4,755 tons per year. To achieve this reduction of accepted waste, the following management practices have been implemented:

Green Waste Management Opportunity Assessment (OA) and Alternate Daily Cover (ADC)
Asphalt and Concrete Re-processing
Landfill Waste Acceptance Controls
Study to Increase the Efficiency of the Recycling Programs

Green Waste Management Opportunity Assessment (OA) and Alternate Daily Cover (ADC)

Historically, Vandenberg AFB generated a considerable amount of both C&D and green waste: 42,162 tons in 1995, 45,536 tons in 1996, and 30,257 tons in 1997.

The C&D waste is generated through the demolition and rebuilding of all military family housing (MFH) units, as well as the continued demolition of old Army facilities. In 1995, this demolition created an influx of 12,409 tons of C&D waste that were disposed of in the base landfill, and 29,575 tons of concrete and asphalt debris, which were diverted from the base landfill and stockpiled at a temporary staging area. For 1996, 16,978 tons were accepted and 25,051 tons were diverted.

Additionally, in 1995, some 4,178 tons of green waste were generated at Vandenberg AFB, with 2,048 tons accepted and 2,130 tons diverted. For 1996, 507 tons were accepted and 3,000 tons were diverted.

To address this issue, a Green Waste Management Opportunity Assessment (OA) evaluated the feasibility of a green waste processing facility at Vandenberg AFB. The evaluation was completed to assist Vandenberg AFB with meeting mandatory waste diversion goals, while adhering to regulatory requirements regarding disposal, facility design, and operation. The OA incorporated the following major components necessary to properly evaluate a green waste management system: green waste generation and characteristics, green waste product evaluation, and cost evaluation.

Four potential uses of processed green waste were identified: alternate daily cover (ADC) at the landfill, direct land application, landscape material, and soil amendment. The primary focus of the OA was ADC, since any green waste, and most C&D materials accepted in a Class III sanitary landfill, have the potential to be processed into ADC, which in California can be counted toward diversion.

Green waste product and cost evaluation was developed through a review of existing alternatives currently being used by other green waste management facilities. This information, combined with a general market assessment for green waste products in the local area, provided a basis for determining the best alternatives available to Vandenberg AFB for a green waste management facility. Facility cost information was included with the basic facility design and siting information to estimate the actual cost savings potential for Vandenberg AFB.

The recommendations in the OA include options that meet the current and future Vandenberg AFB green waste issues. The facility design considered two issues: ability to process large quantities of C&D/green waste for use as ADC; and to process clean green waste for uses such as land application and soil amendment. The facility design evaluation included process description, facility siting, and facility costs. A thorough study was also performed on the types of grinding equipment that should be used in the facility.

As a follow-on to the OA, an ADC project was implemented with the approval of all applicable regulatory agencies such as the CIWMB, the Santa Barbara County Air Pollution Control District, and the Santa Barbara County Department of Environmental Health Services, which is the Local Enforcement Agency (LEA). A 460 horse-power horizontal grinder has been placed at the landfill to convert structural C&D waste and green waste into ADC. The MFH units being demolished have undergone complete asbestos and lead-based paint abatement, however to ensure worker safety, and to avoid any potential adverse environmental impacts, the grinding operation includes monitoring of ambient air.

The ADC project is the beginning of other options to process and use green waste at the base landfill. Other possible uses of the green waste are as a base-wide non-indigenous plant abatement material (covering and smothering exotic plants), and for inclusion in a composting project. These projects comprise the many programs at Vandenberg AFB that are designed to divert waste from the base landfill and meet waste diversion goals.

Asphalt and Concrete Re-processing

Although diverted from the landfill, the asphalt and concrete rubble C&D waste are in themselves challenges for recycling programs. During its first two months of operation, the C&D/green waste grinder has also been used to process some 7,500 to 10,000 tons of asphalt debris, of which some has already been used as to repair roads damaged by winter storms. For the concrete rubble, a crusher is being employed to convert it to usable material, either in new construction projects or for use as rip-rap for drainage control and slope stability at the base landfill.

Landfill Waste Acceptance Controls

As a part of implementing the SWMP, the landfill scalehouse is being automated to better control and manage waste being accepted. Private vehicles and unauthorized contractors are now denied access. A tipping fee has been established for the adjoining Federal Penitentiary, which contributes some 12 percent of the total accepted waste. The purpose of the fee is to encourage

the establishment of a penitentiary recycling program, and to the amount of waste brought to the landfill: the fee increases at an exponential rate beyond an established base tonnage.

Study for Increasing the Efficiency of Recycling Programs

The purpose of this study was to evaluate the efficiency of the current material recovery and recycling operations at Vandenberg AFB, and to conduct an opportunity assessment to explore new and innovative ways of improving recycling programs and making them more cost effective. A cost/benefit analysis provided an economic comparison of the alternatives.

The study included: an evaluation of current recycling and recovery programs, and related aspects; alternative ways to enhance the recycling and recovery programs; an analysis of current participation in recovery and recycling programs through a survey questionnaire, and exploration of ways to increase participation; and an evaluation of the feasibility of recycling materials not in the current collection program. Study target groups were residential, institutional, commercial, and military, based on the differences in operational procedures, and generation of wastes, among these groups.

The waste streams evaluated in the study were separated into commercial, industrial, and residential. The Study focuses on only the recyclable portions of those waste streams. Recyclable materials do not include concrete and asphalt, green waste, asbestos, or hazardous materials/waste. Areas studied to increase the efficiency of the recycling programs included the development of a centralized drop-off center and educational programs. In addition, recycling of alternative materials such as toner cartridges, compact discs, and transparency film were evaluated.

Vandenberg AFB has a refuse and recycling contractor that collects refuse and recyclable materials from each building and residential areas on base. The evaluation of the centralized drop-off center included options for a contractor-operated center or a base-operated center. Options were also provided for manned and non-manned centers. The study recommended that if Vandenberg AFB was to construct a centralized drop-off center, it would be most effective to construct it at the base landfill. This location would provide extra convenience for contractors and base personnel to recycle bulk materials, such as cardboard, or large amounts of metals or plastic that may otherwise stockpile due to infrequent pick-ups by the refuse and recycling contractor. Construction contractors could bring C&D debris to this drop-off center to avoid disposal in the landfill. The MFH residents are already provided with weekly green waste pick-up service, and monthly bulk item pick-up service; therefore, they have opportunities to recycle commonly generated materials.

Although Vandenberg AFB has an educational program to promote recycling on base, the study recommended several options to expand the existing program. An educational program goes hand in hand with the development of any recycling system, including the construction of a centralized drop-off center. From the basewide survey, approximately 40 percent of the survey respondents suggested increasing the educational program as a way to improve and increase

recycling efforts; many of the additional comments made on the survey addressed educational programs.

The study recommends that educational materials be designed to accommodate all of the facilities on base including Air Force and contractor offices, family housing, dormitories, schools, chapels, and recreational facilities. As there is a constant turnover at Vandenberg AFB in all areas of the base, continued education is the key to ensure constant and consistent participation in recycling programs.

Data from the survey indicated that participation in the recycling programs is high; however, responses indicated that paper, cardboard, and aluminum are the most frequently recycled materials. Other materials such as glass, plastics, and magazines are not frequently recycled. This could be interpreted in that either these materials are not being used in a quantity as high as the others, or people are unaware that these materials are recyclable. Regardless, if the base population was aware of the types of items that are recyclable, the rate of recycling these materials could increase. Educational programs recommended include developing a newsletter or some type of publication to be distributed basewide on a regular basis, displaying promotional posters, and/or having training sessions to educate the public about recycling.

Educational materials should also be developed to promote source reduction and affirmative procurement programs, and provide guidelines for the people who make purchasing decisions. Information on hazardous materials alternatives should also be included to promote the purchase of environmentally friendly products. The study recommended the development of an in-house hazardous materials exchange similar to other hazardous materials exchanges in California.

Final recommendations from the study included contract expansion and development of a solid waste functional area. Contracts covering any function on base that would generate types of recyclable waste including office materials, manufacturing, process, maintenance, or C&D waste should be expanded to include explicit provisions to make every effort possible to recycle or reuse wastes. Many contractors are not required to evaluate the waste streams in terms of recyclable or reusable materials. A solid waste functional area manager could be responsible for combining and managing all of the alternatives discussed in this study to ensure that the programs are integrated and remain effective, and enforce and monitor recycling efforts.

Conclusion and Way Ahead

The solid waste management programs at Vandenberg AFB are highly integrated and are geared to work towards achieving waste diversion goals as well as providing pollution prevention programs. For example, in 1997, C&D/ green waste comprised 74 percent of the total solid waste generated at Vandenberg AFB, with 34 percent accepted into the landfill and 40 percent diverted. For the first quarter of 1998, C&D/green waste comprised 77.6 percent of the total solid waste generated; however, only 10.6 percent was accepted and 67 percent was diverted. For the first time, the volume of diverted materials has exceeded that of the accepted waste, which resulted in the elimination of regulatory fees associated with accepted tonnage.

A Recycling Outreach Program has recently been initiated to follow-through on implementing the educational recommendations of the Study for Increasing the Efficiency of Recycling Programs. In addition, process green waste has been effectively used in an ongoing effort to abate non-indigenous plant species.

The pollution prevention and solid waste management programs discussed in this paper help to solve some the problems that arise involving resource recovery and recycling by recommending alternative solid waste management technologies and methods. Each individual entity at Vandenberg AFB is responsible for managing solid waste generated from their organization and each entity should strive to communicate with one another and work together to achieve solid waste management goals. The solid waste programs developed for Vandenberg AFB look beyond financial incentives to achieve base-wide environmental excellence.

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Pilot Demonstration of Hexavalent Chrome Removal and Recovery from ALC Waste Waters for Toxic Sludge Volume Reduction

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ABSTRACT

This paper reports on the successful pilot field tests for assessing the effectiveness of using Anion Liquid Ion Exchange (A-LIX) technology for removal and recovery of toxic but useful hexavalent chromium from U.S. Air Force Air Logistics Centers' (ALC's) industrial wastewater streams. The A-LIX field-testing demonstrated high system operability and excellent Cr^{VI} removal and product concentration. For feed streams with average Cr^{VI} concentrations of 6000 ppb, the field unit consistently produced a raffinate having less than 50 ppb Cr^{VI}. At the same time, the system was able to produce a Cr^{VI} concentrate of greater than 20,000 ppm.

Implementation of the A-LIX system has the potential to reduce sludge waste production at Warner Robins ALC alone by 276 tons per year. Rather than producing sludge as the current precipitation process does, the A-LIX system would produce a potentially reusable Cr^{VI} concentrate. It is concluded that the A-LIX process represents an excellent technical and good economic solution reducing USAF chromium plating shop waste. Therefore it is recommended to proceed to the next step, construction of a prototype commercial unit.

INTRODUCTION

The U.S. Air Force seeks solutions to reduce or eliminate the large volumes of toxic waste sludges that are currently produced at its industrial wastewater treatment plants (IWTPs) servicing its ALC's. These sludges contain varying quantities of hazardous materials, such as heavy metals, waste oils, and halogenated waste. Increasingly stringent environmental discharge regulations and rising disposal costs make it cost efficient to identify, evaluate, and develop candidate technologies to minimize the volume and/or toxicity of these sludges. The work reported in this paper supports this USAF goal through the development of technology for the recovery of hexavalent chromium, a high performance but toxic material, from ALC spent process liquors to reduce the amount of hazardous waste landfilled.

Objective. The objective of this work was to evaluate, at a pilot scale, the application of A-LIX technology for the removal of toxic hexavalent chromium from industrial process wastewater streams. The specific objectives for the project were (1) to validate continuous A-LIX processing for removal and recovery of toxic hexavalent chromium at ALC IWTPs, and (2) to collect process data and use it to prepare an engineering assessment for the scale-up of A-LIX to a commercial full-scale unit.

Background. Screening testing during Phase I of the program identified A-LIX as the preferred hexavalent chrome recovery technology for piloting in Phase II. A-LIX promised to allow not only the removal of trace hexavalent chromium, but also its recovery and concentration to a useful product in one continuous, low maintenance operation. In the A-LIX process, anionic Cr^{VI}, i.e. $HCrO_4^-$, $CrO_4^{=}$, and $Cr_2O_7^{=}$ ions, are recovered by reversible ion pairing with a protonated (cationic) water imiscible tertiary amine, Alamine® 336 (Henkel America, Inc.). The field trials took place at Warner Robins Air Logistic Center (WR-ALC) during the spring and summer of 1997. The WR-ALC IWTP #2 receives about 40,000 gallons per day of spent process wastewater containing 1000 to 10,000 ppb Cr^{VI} along with other impurities from the plating, conversion coating, and painting operations. These Cr^{VI} levels are substantially above regulated discharge levels (100 ppb). Field-testing occurred at Warner Robins ALC using a slipstream of effluent from the chromium-plating sump to IWTP #2. During this testing, data were collected on the effectiveness of E/A ratio, throughput rates, impeller tip speeds, and best means for pH control.

PILOT PLANT DESCRIPTION AND OPERATION

The 1.5 liters per minute pilot-plant was cart mounted for portability. The separations component of the pilot-plant is a Robatel SX-4.0 four-stage mixer-settler unit (Figure 1). Added support equipment for the mixer-settlers included tanks, pumps, and filters. Instrumentation included pH meters, flowmeters, pressure gages, and temperature indicators. Cr^{VI} extraction was controlled using pH swing. The pH was automatically controlled between 3.5 and 6 for the extraction step using 10 percent sulfuric acid. Control of pH in the stripper was through occasional addition of caustic to internally recycled sodium carbonate solution.

During the four months of testing, the pilot unit ran very steadily, needing little attention to maintain a particular operating configuration. Liquids flowed under gravity from stage to stage without plugging. Interfaces between the aqueous and extractant phases remained steady in the settlers. No flooding in any of the tanks or mixer-settlers occurred. The stirrer-pumps performed well, varying no more than 1 rpm from their ~1000 rpm set points per day. An entrainment coalescing oil/water separator was included with the unit to minimize losses of extractant to the raffinate.

Samples were collected and analyzed after the system had time to approach steady state conditions. The following flow streams were sampled: Extractant phase, Extraction raffinate, Final raffinate (post-O/W separator), Stripping solution, and Feed solution. In addition, mixer emulsions were sampled and E/A ratios measured. Cr^{VI} analyses were performed in real time using the Hach Company selective Diphenylcarbazide Colorimetric method. This method was found to be ideal for field-testing.

RESULTS AND DISCUSSION

A sample of the operating conditions for feed pH ~ 3.5 are shown with corresponding Cr^{VI} raffinate concentrations in Table 1. The A-LIX system attained the 50-ppb target Cr^{VI} concentration during the majority of the test runs. The results presented in Table 1 include a test of the value for acidification of the feed stream with 10 percent sulfuric acid to a pH of approximately 3.5 to optimize Cr^{VI} recoveries. The average standard deviation was 10 ppb for runs that met the 50 ppb Cr^{VI} target raffinate concentration (all but one, which was at the highest feed flow rate). Due to the range in values of flowrates, feed concentrations, and pH's tested (not shown), it is concluded that acidification does not appear necessary for high Cr^{VI} recovery yields.

The two stripping units functioned without any mechanical or hydraulic problems. Occasional manual additions of 10 percent NaOH were used to maintain a pH of at least 11 in each unit. In a similar manner, but less frequently, additions of 10 percent Na_2CO_3 were added when the buffering capacity of the strip solution diminished (pH drop too rapid).

Two percent Alamine® 336 extractant solution was tested but it was not possible to operate at extractant/feed (E/A) ratios of 1/5 or lower. Therefore, the remaining tests were run with a 5 percent Alamine 336® extractant solution which was found to perform well.

As expected, E/A ratio affected Cr^{VI} recoveries. There was only one run that did not have an average effluent concentration below 50-ppb (Table 1). This high residual is interpreted to be due to insufficient phase mixing at the high feed throughput and an above average feed concentration, 775 ml/min and 10,500 ppb Cr^{VI} respectively. Values as high as 646 ml/min feed throughput, and 1/9 E/A ratio were obtained in runs that produced acceptable effluent concentrations. These parameter values indicate that a basis of 600 ml/min feed throughput (3 min residence time) and 1/6 E/A ratio are conservative recommendations for a full scale A-LIX system.

Measurement of throughput rates provided the retention time, τ, for mixing and settling. Each mixer was operated with τ equal to about 3 minutes, and each settler with τ equal to about 15 minutes. Higher throughput rates produced lower retention times, but resulted in emulsion carry over to the raffinate. Therefore, improved engineering design enhancements in phase coalescence would be required if higher throughput rates are desired. Previous test data indicate that chemical equilibria are not limiting at these conditions.

By varying the mixing impeller tip speeds in the extraction units, it was found that 1152 rpm produced too fine of an emulsion that led to a hazy raffinate. A small reduction in the impeller tip speed to 1125 rpm produced a clear raffinate. Therefore tests were performed at this lower rate.

Figure 2 shows how the concentration of Cr^{VI} in the first stripping unit continually increased during A-LIX operation. To evaluate whether the system could produce a highly concentrated Cr^{VI} solution, the strip solution in the first stripping unit was spiked with Cr^{VI} . The strip solution was first spiked to ~10,000-ppm Cr^{VI} and then to ~20,000-ppm Cr^{VI}. As Figure 3 shows, the system produced a consistent raffinate of low Cr^{VI} concentration despite these high product Cr^{VI} concentrations. Figure 3 also clearly illustrates the need for two extraction stages. With a feed concentration of about 6400 ppb Cr^{VI}, the concentration after one stage was about 180ppb and the concentration after the second stage was about 15 ppb.

In order to assess the reuse or market value of the concentrated Cr^{VI} product solution an unspiked sample of the concentrate was analyzed (Table 2). These results show the hexavalent

chrome to be quite pure with the exception of the added sulfate (Table 2). This sulfate is not expected to hinder recycle of the hexavalent chrome. The sulfate accumulation rate in the strip solution would be greatly reduced if the pH in the extraction units were maintained at 4.5 rather than 3.5. Hence higher (unadjusted) pH is recommended for commercial operation.

A-LIX ECONOMIC ANALYSIS

An economic analysis of a conceptual, full scale A-LIX system for installation at the WR-ALC IWTP #2 was performed. The following values are the basis for the analysis: feed of 80,000 gallons/day (GPD) and 6 ppm Cr^{VI}, extraction E/A ratio of 1/6, extraction pH of 4.5 and stripping pH of 11, mixer residence times of 3 minutes, settler residence times of 16 minutes, 56 ppm extractant phase in raffinate.

The cost of each of the four mixer settlers would be about $10,000. Including various pumps, tanks, taxes and delivery charges results in an estimated purchased equipment cost of $96,000. Using standard factors for installation, instrumentation, control, piping, electrical, engineering and supervision, construction expense, contractors fees , startup costs, and contingency , a total capital investment (TCI) cost of $383,000 was estimated. Varying the operating parameters has little impact on the TCI because of the system's relatively small size. The total annual operating costs (TAOC) for this full-scale A-LIX system were calculated as $65,600 per year. The sensitivity of the TAOC to parameter variations are also low.

Using these costs, an annual savings of $121,000 can be realized if WR-ALC does not have to dispose of 276 tons of sludge each year, which is attributed to presence of Cr^{VI} . These savings, together with the TCI and TAOC result in an estimated payback periods of 4, 7, and 10 years for the best, nominal, and conservative cases respectively. Increases in waste sludge disposal costs would result in the A-LIX system becoming even more attractive economically. For example, a 50 percent increase in the disposal costs would reduce the estimated payback periods to 2, 3, and 4 years. Capital cost savings may be possible by complete shop fabrication of the small system to minimize field construction, and piping costs..

CONCLUSIONS AND RECOMMENDATIONS

The results of the A-LIX field-testing indicate that a 50-ppb Cr^{VI} effluent target can be consistently met under the following operating conditions: feed throughput of 600 ml/min or less, E/A ratio of at least 1/6 , extraction pH of ~4.5, and strip pH of ~11, 5 percent Alamine® 336 concentration, and 2 Extraction units.

In addition, it was demonstrated that the system could produce a concentrated Cr^{VI} product of at least 20,000-ppm without disrupting the production of the <50 ppb effluent.

With the success of the A-LIX pilot plant operation, it is recommended that either OC-ALC, OO-ALC, or WR-ALC be chosen as the site for construction of a prototype A-LIX unit. (At Tinker or Hill, the A-LIX system would take the place of the current Cr^{VI} pretreatment systems.) The unit would be of commercial grade construction and design, and would require minimal operator attention. This prototype unit would be used to generate long-term continuous performance data, and generate Cr^{VI} concentrate for reuse/recycle evaluation. From this system,

detailed design and economic analysis could be developed, so that "turn key" units and operational procedures would be available to other sites.

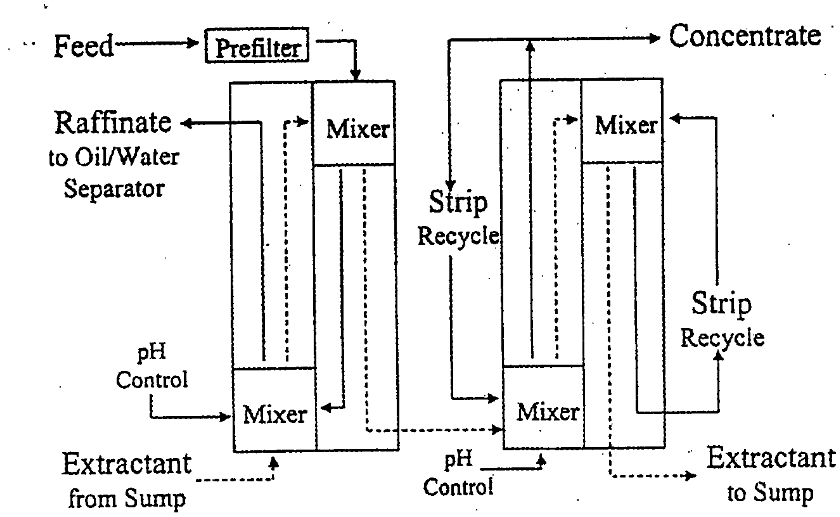

Figure 1. A-LIX Test System.

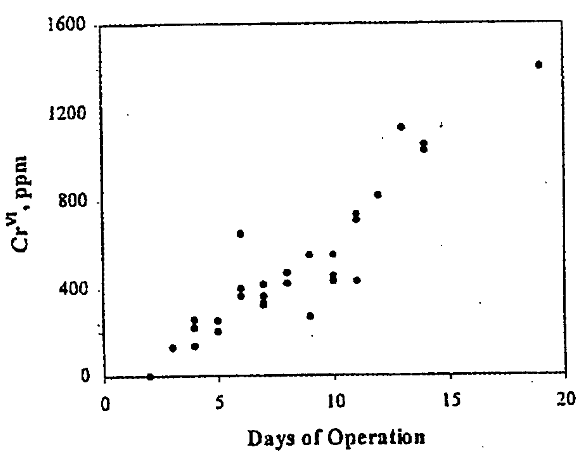

Figure 2.
A-LIX Results: Cr^{VI} Accumulation in the First Stripping Stage.

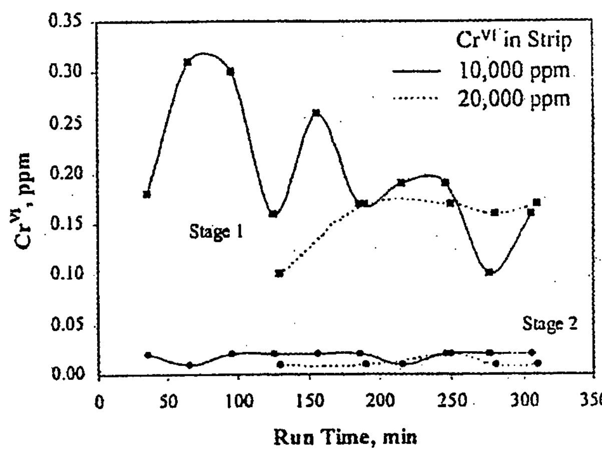

Figure 3.
A-LIX Removal of Cr^{VI} from a Feed Concentration of 6.4 ppm.

TABLE 1. RESULTS OF A-LIX FIELD-TESTING.

Sample Number	Feed Cr^{VI} ppb	Feed Flow Rate ML/min	pH	E/A Ratio	Raffinate $[Cr^{VI}]$, ppb Average
1	3900	505	3.5	1/5	37
2	2900	516	3.5	1/5	<10
3	6400	516	3.5	1/5	14
4	6400	516	3.5	1/7	25
5	10,500	775	3.5	1/6	178
6	7000	646	3.2	1/6	40
7	4600	644	3.3	1/6	27
8	4600	505	3.2	1/9	32
9	6400	514	3.5	2/9	18
10	6400	500	3.3	1/4	12
Average	**5900**	**564**	**3.4**	**1/6**	**38**

TABLE 2. ACCUMULATED SPECIES IN THE STRIP SOLUTION.
Actual Product Solution is expected to be at least 20,000 ppm in Cr^{VI} (see text).

Constituent	Concentration, ppm
Total Organic Carbon	613
Fluoride	1.95
Sulfate	15,500
Total Kjeldahl Nitrogen	20
Aluminum	8.09
Calcium	11.6
Cadmium	< 0.01
Chromium (VI)	**1,400**
Copper	0.17
Iron	0.84
Magnesium	1.30
Manganese	0.12
Nickel	0.97
Lead	0.69
Zinc	0.25

SESSION XXV
NEW TECHNOLOGIES

SESSION CHAIRPERSONS:

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Development of Biodegradable Hydraulic Fluids for Military Applications

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Background

Hydraulic systems are essential component of military equipment ranging from aircraft flight control systems to construction equipment. A common factor in most hydraulic systems is the potential for leakage and the possibility of spillage of hydraulic fluid during storage and use. The generation of the hazardous wastes by petroleum based or synthetic fluids results in both short and long term liability in terms of costs, environmental damage, and mission performance. Currently, the Resource Conservation and Recovery Act (RCRA) and DoD Hazardous Minimization (HAZMIN) Policy mandate that all military installations must reduce the quantity or volume and toxicity of hazardous waste generated by petroleum based products wherever economically practicable and environmentally necessary. To achieve the environmental goals, a number of recycling, re-refining, incineration, and field bioremetiation technologies were recently used in the field, but with limited success. For this reason, Fuels and Lubricants Technology Team of U.S. Army Tank-Automotive Research, Development and Engineering Center is currently developing Biodegradable Hydraulic Fluids (BHFs) to replace military industrial and mobility hydraulic fluids which are less compatible with environment.

In response to the demand of military BHFs, a market study was conducted in 1994 to determine whether renewable hydraulic fluids would be suitable in military applications. In this study, total twenty-six (26) renewable hydraulic fluids were evaluated against the requirements of MIL-H-46001[1] as most samples were designed as industrial hydraulic fluids. The result showed that most renewable hydraulic fluids tested were very close to meeting requirements of MIL-H-46001 specification and were promising as candidate biodegradable military hydraulic fluids. These results were published in TARDEC Technical Report[2] entitled " Evaluation of Environmentally Acceptable Hydraulic Fluids". However, these renewable products must be reformulated for use in military applications as they were originally designed for the limited commercial applications. Further development of this effort was devoted to develop the target requirements for BHF and to conduct the field validation for these renewable products. This paper review market study, and describes the market study, target requirement of BHFs, laboratory test results, finding, and details the field demonstration that is being currently conducted at Fort Bliss, TX.

Market Survey

A market survey for BHFs has been conducted to determine whether renewable hydraulic fluids would be suitable in military applications. The approach used in this study was to review laboratory data and current technology used in BHFs, and to determine availability of BHFs including manufacturers. Currently, there are two types of BHFs available. These types of fluids are either vegetable based or synthetic ester based. Each of these fluids has significant different

characteristics from conventional mineral oil. As a follow-up action, twenty-six (26) renewable hydraulic fluids were evaluated against the requirements of military industrial hydraulic specification, MIL-H-46001[2].

Vegetable oils have excellent lubrication qualities and are nontoxic and biodegradable. They are made from renewable resources such as rapeseed, sunflower, corn, canola and soybean, and are much less expensive than synthetic fluids. Their chemical structures are triglycerides in which a variety of saturated, monounsaturated or polyunsaturated fatty acids are esterified to a glycerol backbone.. The physical properties of a vegetable oil depend on the nature of its fatty acid composition. This oil tends to oxidize at temperature above 90 °C and short life compared with conventional petroleum-based fluids, Also, it has a limited low temperature capability (-15 °C). This significantly affects the outdoor mobility applications where hydraulic systems may sit for extended period at sub-zero temperatures. However, only one type of viscosity grade (i.e., ISO 32) is available due to its limited manufacturing process.

Synthetic esters, mainly based on trimethylopropane, polyol ester and pentaerythritol, are regarded as the best among the biodegradable base fluids. The biodegradability of these oils is comparable to vegetable oils and their lubrication properties are very similar to mineral oils. The advantages of these oils are excellent fluidity, and low temperature and aging stability. Because of these, they provide wide operational temperatures (-54 to 150 °C) and have long shelf and service lives. One the other hand, the cost of synthetic esters is much higher than those of mineral oils. Their differences are summarized in Table 1.

Table 1. Comparison of Base Fluids

	Mineral Oils	Vegetable Oils	Synthetic Esters
Biodegradability ASTM D 5864, %	10-40	40-80	30-80
Viscosity Index	90-100	100-250	120-220
Pour Points, °C	-54 to –15	-20 to 10	-60 to –20
Compatibility with Mineral Oils	-	Good	Good
Oxidation Stability	Good	Poor to Good	Poor to Good
Service Life	2 yrs	6 month to 1 yr	3 yrs
Relative cost	1	2 to 3	4-6

It was found that BHFs also require additive to enhance performance. Antioxidations, corrosion inhibitors and pour point stabilizers can improve the lubrication properties of some vegetable oils such as rapeseed oil and synthetic esters. However, the use of conventional additives in BHFs may pose potential problems on the fluid's biodegradability and ecotoxicological properties due to the toxicity of chemicals. Thus, domestic additive manufacturers are also investing in developing the BHF additives, which are compatible with BHFs. Some environmentally acceptable additives such as sulfur-carriers have been developed and are currently available in domestic market.

Development of Preliminary Target Requirements for BHFs

The new target requirements for military BHFs were developed based on the specific military needs and what is believed to be achievable with the current BHF formulation technology. Most target requirements were consolidated with the current military hydraulic fluid specifications (MIL-H-46001, MIL-H-6083, MIL-H-46170)[3,4]. These target requirements were designed for Types I and II, which tend to cover all types of renewable hydraulic fluids such as vegetable or synthetic biodegradable fluids. Especially, Type I was designed for vegetable-based hydraulic fluids, while the synthetic BHFs are listed as Type II fluids. These fluids were also divided into five categories based on the ISO viscosity grades. Table 2 lists the preliminary target requirements for BHFs.

To develop a BHF specification, the preliminary target requirements tend to cover a wide operational temperature ranges (-54 to 150 °C), a high biodegradability, a wide viscosity ranges, excellent antiwear and load carrying capacity, good elastomer compatibility, good oxidation stability, good fire resistance, and excellent rust and corrosion protection. Most test methods specified in these requirements were the ASTM standard test methods that are normally used for evaluating the current military hydraulic fluids. Specially, an ASTM biodegradable test method was adopted to evaluate the biodegradability of BHFs. This test method was designed to determine the degree of aerobic aquatic biodegradation of fully formulated lubricants or additives on exposure to an inoculum under laboratory conditions. A toxicity test is also required to assess the environmental properties.

To verify the preliminary target requirements, eleven (11) interim BHFs were reformulated by several lubricant companies and tested according to the testing protocol. The test results obtained to date are presented in Table 3. All interim products met most requirements and provided very high flash and fire points that are compare with those of military fire resistant type hydraulic fluids. The rapeseed–based fluid provided the highest biodegradability among all the fluids. Some of fluids having a high viscosity had a difficulty meeting the target requirement of biodegradability due to their heavy molecular weight and the types of materials. This target requirement may be readjusted to accept new BHFs.

Field Demonstration

As a result of the successful completion of earlier phases of this program, a field demonstration was initiated at Fort Bliss, TX using five (5) BHFs (i.e., rapeseed oil, canola oil, soybean oil polyol ester, diester) and ten (10) construction equipment (i.e., scoop loaders, dump trucks, road graders, etc.). The test samples and equipment are listed in Table 4. For the test, the existing hydraulic fluids were completely removed from equipment prior to the introduction of BHFs. To verify the test results, each BHF was set up in two different types of equipment. The evaluation criteria used in this demonstration are their field performances (i.e., oxidation, viscosity change, wear problem, corrosion protection, seal problem, etc.) and environmental performances (i.e., biodegradability, toxicity). The duration of these tests was designed as one year. The field test is currently conducted by the TARDEC Fuels and Lubricants Research Facility of Southwest Research Institute (SwRI). A quarterly progress review was performed at the each site, and field samples were collected for the laboratory analysis.

Although the field demonstration is not completed, the interim results showed that all candidate BHF samples did not give any abnormal behavior during six month and provided excellent service. However, the laboratory tests are being conducted and the results will be reported at the end of the field demonstration.

Conclusions

On the basis of the work completed to date, Most BHFs were very close to meeting the proposed target requirements and are promising as the candidate military BHFs. As a follow-up action, a field demonstration is being conducted at Fort Bliss. Based on the interim results, BHFs do not create any abnormal behavior when compared to the conventional hydraulic fluids. Therefore, BHFs can be used in selected military hydraulic systems. The results of this study are summarized in the following finding:

- Numerous BHFs are currently available in domestic market and new products are being developed to meet the commercial and military requirements.
- BHFs are biodegradable and less toxic products, and were formulated using vegetable oils (i.e., rapeseed, sunflower, corn, soybean, canola) and synthetic esters.
- Vegetable-based BHFs have limited operational temperature ranges (-10 °C to 90 °C) due to poor thermal and low temperature stability. On the other hand, synthetic ester based fluids showed wide operational capability (-54 °C to 150 °C) which can be used as military mobile hydraulic fluids
- Proposed target requirements were developed based on the market study and military specific requirements.
- Eleven (11) interim BHFs were formulated by the lubricant industries and were evaluated against the target requirements. Most of These products were very close to meeting the target requirements.
- A field demonstration was initiated using five (5) BHFs and ten (10) construction equipment (i.e., Loader Backhole, Dump truck, Grader road, etc.) at Fort Bliss, TX. Although the field test is not completed, all field samples gave a good performance and did not show any abnormal behavior in the selected construction equipment.
- As a plan, this field demonstration will be extended to the military tactical vehicle applications (i.e., tanks, artillery, etc.).

References

1. Military Specification MIL-H-46001, Hydraulic Fluids, Petroleum Based, For Machine Tools, 7 December 1989.
2. In-Sik Rhee "Evaluation of Environmentally Acceptable Hydraulic Fluids", NLGI Spokesman, 1996.
3, Military Specification MIL-H-6083, Hydraulic Fluid, Petroleum Base, For Preservation and Operation, 8 February 1990.
4. Military Specification MIL-H-46170, Hydraulic Fluid, Rust Inhibited, Fire Resistant, 17, November 1993.

Table 2. Target Requirements for Military Biodegradable Hydraulic Fluids

Test	Method	Type I	Type II				
			A	B	C	D	E
ISO Grade	ASTM D2422	NR	15	32	46	68	100
Viscosity, 40 °C min, cSt	ASTM D445	34.2-41.8	13.5-16.5	28.8-35.2	41.4-50.6	61.2-74.8	90.0-110
Viscosity Index, min	ASTM D2270	184	140	140	140	140	140
Viscosity, -15°C, max, cSt	ASTM D445	2300	200	1000	1300	1500	NR
Pour point, °C, max	ASTM D97	-25	-54	-40	-26	-26	-12
Flash point, °C, min	ASTM D92	250	180	240	240	250	250
Fire point, °C, min	ASTM D92	320	190	260	260	260	260
Acid or base number, mg KOH/g, max	ASTM D664	1	1	1	1	1	1
Water content, %, max	ASTM D1744	0.05	0.05	0.05	0.05	0.05	0.05
Rust prevention	ASTM D665B	pass	pass	pass	pass	pass	pass
Copper corrosion, max	ASTM D130	1b	1b	1b	1b	1b	1b
Galvanic corrosion	FTM 5322	pass	pass	pass	pass	pass	pass
Low temperature stability, -15 °C, 72 hrs	FTM 3458	pass	pass (-54 °C)	pass	pass	pass	pass
Oxidation stability (PDSC), minutes, min	ASTM D6186	20 (155 °C)	20 (180 °C)	20 (180 °C)	20 (180 °C)	20 (180 °C)	20 (180 °C)
Thermal stability, mg/100 ml, max	ASTM D2070	25	25	25	25	25	25
Swelling of synthetic rubber, NBR-L, %, max	FTM 3603	35	35	35	35	35	35
Evaporation loss, %, 100 °C, 1 hr, max	ASTM E1131	2	2	2	2	2	2
Four ball wear, mm, max	ASTM D4172	0.65	0.65	0.65	0.65	0.65	0.65
Biodegradability, %, min	ASTM D5864	60	60	60	60	40	40
Toxicity, min	ASTM D6046	1000	1000	1000	1000	1000	1000
Foaming	ASTM D892	65/10	65/10	65/10	65/10	65/10	65/10
Workmanship	Army method	pass	pass	pass	pass	pass	pass
Particle size[1]	particle counter	pass	pass	pass	pass	pass	pass
Storage stability[2], 100 °C, 1 month	Army method	pass,	pass	pass	pass	pass	pass

1. Particle size ranges — Allowable number (max)

Particle size ranges	Allowable number (max)
5-25	10,000
26-50	250
51-100	50
over 100	10

2. Storage stability

Viscosity change	10 %
PDSC, induction time change	10 %
Acid number change, mg, max	2 mg

Table 3. Biodegradable Hydraulic Fluids – Physical property Data

Product Code	Type	Base stock	Viscosity 40 °C	Viscosity -15 °C	Pour point °C	Flash point °C	Acid No.	Four ball wear, mm	Biodegradability, %
A	I	Canola	35.8	575.5	-30	284	0.79	0.4	80
B	I	Rapeseed + Mineral oil	40.2	ND*	-12	318	0.54	0.58	73
C	I	Soybean	48.3	953.9	-26	266	2.17	0.3	60
D	I	Canola + Polyol ester	42.3	695	-37	254	2.10	0.4	71
E	I	Rapeseed	39.2	649.8	-30	316	1.32	0.55	67
F	I	Canola	41.3	ND	-39	216	2.35	0.3	62
G	IIA	Dibasic ester + vegetable oil	13.9	ND	-60	250	0.83	0.3	48
H	IIB	Dibasic ester + vegetable oil	33.6	ND	-60	242	0.82	0.33	ND
I	IIC	Dibasic ester + vegetable oil	52.7	ND	-60	250	0.88	0.33	ND
J	IID	Dibasic ester + vegetable oil	81.6	ND	-60	242	0.96	0.35	ND
K	IIE	Dibasic ester + vegetable oil	116.6	ND	-60	252	0.93	0.34	41

* Not determined

Table 4. Field Demonstration of Biodegradable Hydraulic Fluids at Fort Bliss, TX

Code	Construction Equipment	Candidate BHF	Laboratory product code
FBHF1	Loader Backhoe (John Deere)	Rapeseed oil	E
FBHF2	Dump Truck (International)	Canola oil	A
FBHF3	Dump Truck (GMC)	Canola oil	F
FBHF4	Dump Truck (International)	Soybean oil	C
FBHF5	Grader Road 130 G	Soybean oil	E
FBHF6	Loader Scoop MW24C	Canola oil	A
FBHF7	Grader Road	Rapeseed oil	C
FBHF8	Grader Road 130 G	Synthetic oil	H
FBHF9	Loader Scoop	Synthetic oil	H
FBHF10	Wrecker Truck M816	Canola oil	F

Environmental temperature ranges: 10 °F- 100 °F

DEVELOPMENT OF AN ADVANCED ZINC PHOSPHATE METAL PRETREATMENT

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ABSTRACT

A SERDP-sponsored program aims at developing environmentally benign zinc phosphate conversion coatings and their process technologies for the electrogalvanized steel (EGS). we succeeded in formulating an environmentally acceptable phosphate solution without Co- and Ni-related additives, and also in replacing a hexavalent Cr acid sealant applied over the zinc phosphate (Zn@Ph) layers with a water-based polysiloxane sealers. The specific advantages of the newly developed Zn@Ph coatings were as follows: 1) there was rapid growth of uniform, dense embryonic Zn@Ph crystals on the EGS surfaces due to the creation of short-circuited cells with Mn acting as the cathode and the galvanized (zinc) coatings as the anode, 2) an excellent protection layer against corrosion was formed, extending the service life of zinc layers as galvanic sacrifice barriers, and 3) adhesion to the electro-deposited polymeric primer coating was improved because of the interaction between the siloxane sealer and primer. A full-scale demonstration to evaluate the reproducibility of this new coating technology on mini-sized automotive door panels made from EGS was carried out in collaboration with the Palnut Company (as industrial coating applicator) in New Jersey. All of the 150 mini-door panels were successfully coated with Zn@Ph.

1. Introduction

In the previous SERDP-sponsored program aimed at developing environmentally benign zinc phosphate conversion coatings and their process technologies for cold-rolled steel (CRS) substrates [1], we succeeded in formulating an environmentally-acceptable phosphating solution without Co- and Ni-related additives. The basic formulation consisted of 5 wt% $Zn_3(PO_4)_2$@$2H_2O$, 10 wt% (86 % H_3PO_4), 3 wt% poly(acrylic acid) [p(AA)] and 82 wt% water; appropriate amounts of the $Mn(NO_3)_2$@$6H_2O$ and $FeSO_4$@$7H_2O$ as additives were incorporated into this basic formulation. These additives had two important functions; one was to create a large number of nucleated sites of embryonic Zn@Ph crystals on the steel surfaces, and the other was to act as an inhibitor of corrosion. The p(AA)-modified Zn@Ph coatings not only displayed an excellent salt-spray resistance of > 1000 hrs, but also showed a strong electrochemical affinity with the electro-deposited polymeric primer coatings.

2. Experimental Details

2.1 Materials

The metal substrate used was ASE 1006 cold-rolled steel coated with electroplated zinc (EGS, Ford E 60 Electrozinc 60G), supplied by Advanced Coating Technologies, Inc. The formulation for the basic zinc-phosphate liquid

was 5.0 wt% zinc orthophosphate dihydrate (Alfa Co.), 10.0 wt% H_3PO_4, 1.0 wt% $Mn(NO_3)_2$@$6H_2O$ (Alfa Co.) and 84.0 wt% water. A water-based polysiloxane sealant, 3-aminopropyltrimethoxy-silane (APS) monomer was supplied. The APS precursor sealant consisted of a 7 wt% APS, 3 wt% methyl alcohol, 0.7 wt% hydrochloric acid and 89.3 wt% water, and had a pH of 9.96. In preparing the polymeric primer coating, all the APS-sealed Zn@Ph panels were coated with the polyurethane-modified epoxy copolymer (POWERCRON 648) by electrodeposition technology at Advanced Coating Technologies, Inc. The polymeric primer was cured in an oven at . 177EC for 30 min.

2.2 Measurements

Scanning electron microscopy (SEM) was used to investigate the degree of coverage of the EGS surfaces by p(AA)-modified Zn@Ph coatings and explore the alteration in morphological feature of crystalline Zn@Ph coatings as a function of immersion time. The surface chemical states and phase identification of the coating were carried out using x-ray photoelection spectroscopy (XPS) and x- ray diffraction (XRD). The concentration of zinc ions dissociated from the EGS surfaces in single H_3PO_4 and $Mn(NO_3)_2$@$6H_2O$ aqueous solutions, and in their combined medium was determined by atomic absorption spectrophotometry (AA).

DC potentiodynamic polarization measurement for data on the rate of corrosion. The tests were conducted in an aerated 0.5 M NaCl solution at 25EC, on an exposed surface area of 1.0 cm^2. AC electrochemical impedance spectroscopy (EIS) was used to evaluate the ability of coating films to protect the EGS from corrosion. Specimens with a surface area of 13 cm^2 were exposed to an aerated 0.5 N NaCl electrolyte at 25EC, and single-sine technology with an input AC voltage of 10 mV (rms) was used over a frequency range of 10 kHz to 2 MHz. The salt-spray tests for the primed Zn@Ph coating panels were carried out in accordance with ASTM D1654-79a.

3. Results and Discussion

3.1 p(AA)-Modified Zn@Ph Coatings on EGS

Figure 1 shows SEM micrographs of crystalline Zn@Ph coatings derived from the p(AA)-modified phosphating solutions as a function of the immersion time of the EGS substrate into the phosphating bath at 80EC. Immersion for 5 sec was sufficient to produce dense conversion coatings over the entire substrate surface **(see Fig. 1-c)**. A immersing time to 10 sec (d) revealed a densely packed conformation of lamellar Zn@Ph crystals, reflecting that the EGS surface had essentially been altered and now had a rough microstructure.

Figures 2 and 3 show the high-resolution XPS spectra of P_{2p}, $Zn_{2p3/2}$, and C_{1s} core-level excitations for the Zn@Ph coatings as a function of treatment time. Because the peak at 1023.0 eV belongs to Zn originating from Zn@Ph [8], this result strongly supported the SEM data showing that an immersion of 5 sec is long enough to cover the whole surface of EGS with Zn@Ph. An important question remains to be solved: namely, why the $Mn(NO_3)_2$@$6H_2O$-incorporated solution causes the rapid deposition of Zn@Ph on the EGS surfaces. $Mn(NO_3)_2$@$6H_2O$ solution, . 2.7×10^{-4} g/ml of Zn ions dissociate from the EGS surfaces in the first 2 sec of immersion; thereafter, the rate of Zn ion dissolution increases with increased time **Figure 4**. These findings verified that the addition of $Mn(NO_3)_2$@$6H_2O$ to H_3PO_4 solution significantly promotes the dissolution of Zn ions from the EGS surfaces in conjunction with a more brisk evolution of hydrogen with Zn acting as the anodic area and Mn as the cathode. Mn side:

$$2H_3PO_4 \; 6 \; 2H^+ + 2H_2PO_4^-$$

$$2H^+ + 2e \; 6 \; H_2$$

From this information, we show the hypothetical conversion mechanisms of Mn-incorporated H_3PO_4 solution into zinc phosphate phase over the EGS (**Fig 5**). **Figure 6** illustrates the XRD tracing, ranging from 0.444 to 0.225 nm, of the "as-received" EGS as a control, and the p(AA)-modified Zn@Ph coatings prepared by immersing EGS panels for 1, 2, 5, and 10 sec

3.2 Water-Based APS Sealant

All Zn@Ph coatings contain some voids remain in the coating layers. These must be filled for maximum corrosion protection. The goal of this part of the research was on the non-toxic, water-based APS sealant used to replace the conventional toxic hexavalent chromic acid as corrosion-inhibiting sealant.

In the XPS study earlier, we found that the p(AA) polymers remain at the outermost surface sites of Zn@Ph layers. Thus, it is very important to know how the APS sealer reacts with the p(AA) polymers chemisorbed to the Zn@Ph. The results strongly demonstrated that when the APS was attached to the p(AA), the NH_2 groups in APS favorably reacted with the carboxyl in p(AA) to form the amide bonds. Thus, it is conceivable that the formation of interfacial amide bonds acts to link strongly p(AA) to the APS films and are illustrated in **Fig A**.

Figure 7 depicts typical polarization curves log current versus potential for the uncoated EGS, and Zn@Ph-and p(AA)-Zn@Ph-coated EGS panels. When compared with those for the uncoated EGS, the form of the cathodic curves for

the coated EGS specimens are as follows: (1) a decreased current in the vicinity of E_{corr}, and (2) a lower short-term steady-state current value in the potential region between -1.2 and -1.0 V. As a result, it appears that the ability of zinc layers in the EGS to inhibit the cathodic reaction in terms of the oxygen reduction reaction, $H_2O + 1/2O_2 + 2e^- \rightarrow 2OH^-$, of the underlying steel was further enhanced by the p(AA)-modified and unmodified Zn@Ph coatings. Thus, we believe that the formation of interfacial amide bonds by the interaction between APS and p(AA) significantly contributes to protecting steel from the corrosion, suggesting that the APS has a high potential for use as sealer of the p(AA)-modified Zn@Ph coatings.

Based upon these polarization curves **Figure 8**, we attempted to determine the absolute corrosion rates of steel, expressed in the conventional engineering units of milli-inches per year (mpy). The equation (1) proposed by Sterm and Gery [19], was used in the first step:

$$I_{corr} = \beta_a \cdot \beta_c / 2.303 (\beta_a + \beta_c) R_p \text{ ----------- } (1)$$

where I_{corr} is the corrosion current density in A, β_a and β_c having the units of volts/decade of current refer to the anodic and cathodic Tafel slopes. **Table 1** gives the I_{corr} and corrosion rate obtained from this Tafel calculation for various coating panels. A significant decrease in corrosion rate can be seen from the APS-sealed panels, especially in the APS/p(AA)-Zn@Ph coating system. The rate of 0.022 mpy for this coating system was approximately two orders of magnitude less than that of the uncoated EGS.

In support, all the test panels were exposed in a 5 % salt fog chamber at 35EC to determine the extension of useful lifetime of the coatings that protect the zinc layer in EGS against white rusting. The results from these test panels are shown in **Table 2.**

3.3 Electrically Deposited Primer Coatings

We verified that the APS sealed Zinc Phosphate surface could be E-Coated. We did this using PPG's Powercron 648 chemistry **Figure B**. To gain this information, we electrically deposited the primer coatings onto the APS-sealed and unsealed Zn@Ph layers, and then examined the ability of primer coatings to further improve the protection of EGS against corrosion by AC electrochemical impedance spectroscopy (EIS) and the 5 % salt-spray tests.

Six different coating systems, electrically deposited primer (EDP), EDP/Zn@Ph, EDP/p(AA)-Zn@Ph, EDP/APS, EDP/APS/Zn@Ph, and EDP/APS/p(AA)-Zn@Ph, were prepared for this examination.

In the EIS tests, the curves (not shown) for all the coated EGS panels depicted the Bode-plot features [the absolute value of impedance *Z* (ohm-cm^2) vs. frequency (Hz)]. This information was correlated directly with the states

of primer-coated panels after salt-spray tests for 1080 hours. The results from these test panels are shown in **Table 3.**

3.4 Industrial-Scale Demonstration Tests

To demonstrate the reproducibility of this coating technology on mini-sized automobile door panels made from EGS, a full-scale feasibility test was carried out in collaboration with the Palnut Company, NJ. Coating involved the cleaning, coating, rinsing, sealing, and drying (**Fig. 10**). The four separate solution tanks with a 1514 L (400 Gal.) were used. To ensure that this coating process was reproducible, the procedure was repeated ten times; all 150 mini-sized door panels were successfully coated with Zn@Ph.

4. Conclusions

We modified the surface of electrogalvanized steels (EGS) to inhibit corrosion of Zn layers and to improve their sealer-adhesion properties by Immersing EGS panels into environmentally acceptable zinc phosphating solutions consisting of $Zn_3(PO_4)_2$@$2H_2O$, H_3PO_4, poly(acrylic acid)[p(AA)], $Mn(NO_3)_2$@$6H_2O$ and water at 80EC. The electrochemical reaction between Mn dissociated from $Mn(NO_3)_2$@$6H_2O$ and Zn in the acid media created short-circuited cells by the flow of electrons from Zn acting as the anode to Mn as the cathode. Uniform hopeite layers completely converting over the EGS surfaces were observed on the specimens prepared by immersion for only 5 sec, thereby conferring good protection layers against corrosion. Hexavalent Cr acids known to be environmental hazards are commonly used as a sealant for the Zn@Ph layers because they improve the ability of Zn@Ph to protect the metal from corrosion. Hence, our attention was paid to find the replacing materials for the Cr acids. We succeeded in developing an environmentally acceptable water-based 3-aminopropyltrimethoxysilane (APS) sealant. In addition, the APS sealer had a strong chemical affinity for the polyurethane-modified epoxy primer coating induced by the electrodeposition technology. We concluded this test by running a scale up demonstration at the Palnut Company, using a 400-gallon industrial size tank. In all 150 panels were successfully coated with APS-sealed Zn@Ph.

5. Recommendations

1. The optimum formulation for an environmentally benign zinc phosphating solution suitable for (EGS) was 5 wt% $Zn_3(PO_4)_2$@$2H_2O$ powder, 10 wt% (85 % H_3PO_4), 1.0 wt% $Mn(NO_3)_2$@$6H_2O$, and 84 wt% water, in conjunction with poly(acrylic acid) [p(AA), M.W. 60,000] additive of 3.0 wt% by total weight of basic zinc phosphating solution.

2. The water-based 3-aminopropyltrimethoxysilane (APS) sealant consisting of a 7 wt% APS, 3 wt% methyl alcohol, 0.7 wt% hydrochloric acid, and 89.3 wt% water, can be used to replace the conventional hexavalent Cr acid sealant.
3. Using the process technology developed in this work, the p(AA)-modified zinc phosphate (Zn@Ph) conversion coatings with a APS sealer were prepared in according with the following sequence: 1) pickling the EGS panels in a 2 wt% H_3PO_4-1 wt% H_2SO_4-97 wt% water solution for 1 min at 25EC, 2) immersing the surfaces-cleaned EGS panels for 1 min into the p(AA)-dissolved zinc phosphate solution at 80EC, 3) rinsing the Zn@Ph-coated EGS surfaces with water, 4) dipping the water-rinsed Zn@Ph coating panels for few seconds into a 7 wt% APS sealing agent at 25EC, and 5) drying the APS-wetted Zn@Ph coating panels for 30 min in an oven at 150EC.
4. Conduct a long-term exposure in a corrosive environment to ensure that they afford an adequate protection of EGS against corrosion.

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Table 1. Tafel Analyses for Polarization Curves of Coated EGS Panels

Coating	E_{corr}(I=0) V	β_a V/decade	β_c V/decade	I_{corr} A	Corrosion rate mpy
Uncoated	-0.8711	0.0669	0.1513	3.17×10^{-6}	1.449
Zn@Ph	-0.9692	0.0472	0.1660	1.11×10^{-6}	0.505
p(AA)-Zn@Ph	-0.9609	0.0668	0.1547	1.03×10^{-6}	0.467
APS	-0.8293	0.0458	0.1312	3.10×10^{-7}	0.142
APS/Zn@Ph	-0.8453	0.0532	0.1227	2.12×10^{-7}	0.097
APS/p(AA)-Zn@Ph	-0.8421	0.1257	0.1634	4.78×10^{-8}	0.022

Table 2. **Salt-Spray Resistance of Coated EGS Panels**

Coating	Salt-spray resistance Hr
Uncoated	15
Zn@Ph	190
p(AA)-Zn@Ph	264
APS	340
APS/Zn@Ph	612
APS/p(AA)-Zn@Ph	750

Table 3. **Evaluation of EDP-Coated EGS Panels Subjected to 5% Salt Spray Testing**

Coating	Exposure hr	Representative mean creepage from scribe mm	Area of blister formed in inscribed areas %
EDP	360	10.0	80
EDP/Zn@Ph	1080	8.5	32
EDP/p(AA)-Zn@Ph	1080	6.5	28
EDP/APS	1080	3.0	20
EDP/APS/Zn@Ph	1080	1.8	13
EDP/APS/p(AA)-Zn@Ph	1080	1.2	5

Figure 10

1. **Pickled (2 wt% H_3PO_4-1 wt% H_2SO_4-97 wt% water) for 1 min at 25EC**
2. **Immersed in zinc phosphate solution for 1 min at 80EC**
3. **Rinsed with water**
4. **Dipped in water-based polysiloxane sealant**
5. **Oven-dried for 30 min at 150EC**
6. **Electrodeposited primer coatings**

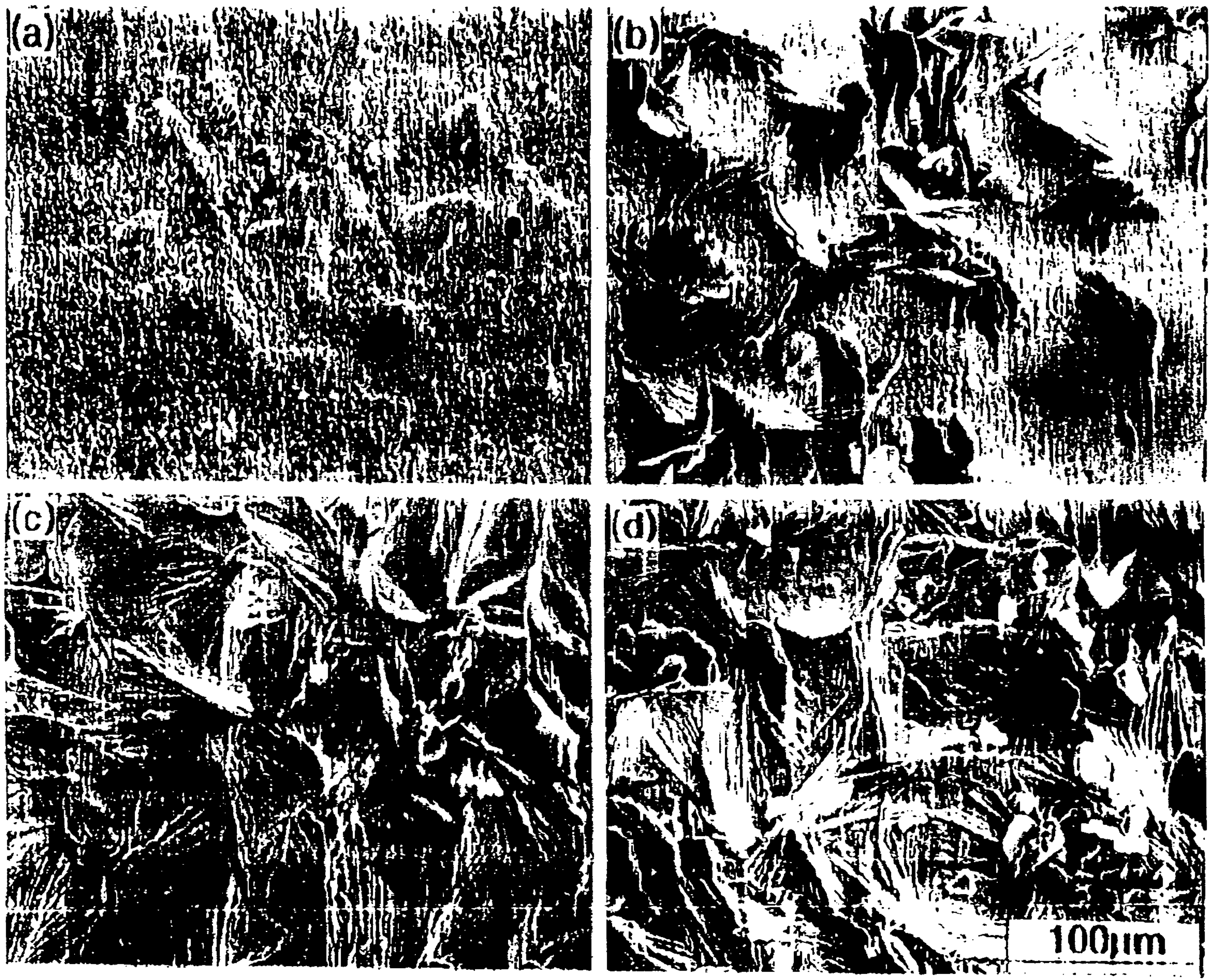

Figure 1 SEM image of (GAA) modified zinc phosphate deposited rapidly on EGS surfaces after immersion for 1 sec (a), 2 sec (b), 5 sec (c), and 10 sec (d)

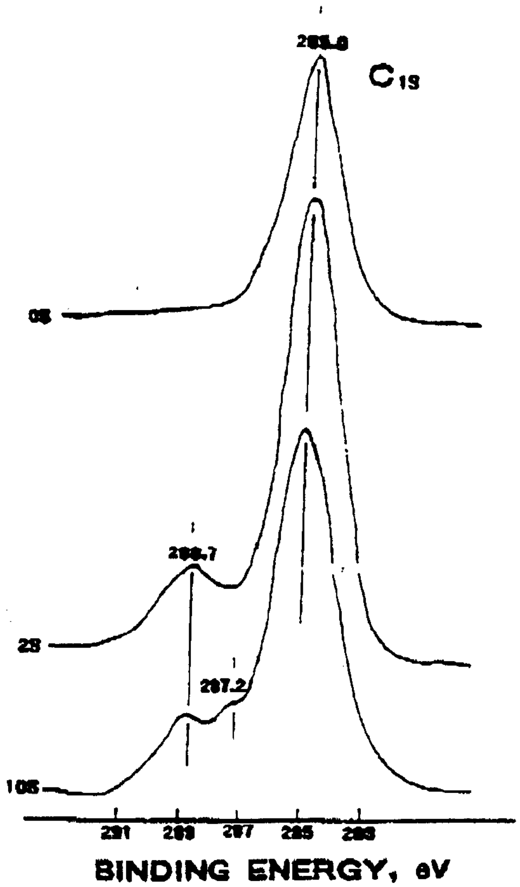

Figure 3. C_{1s} region of "as-received" EGS (0S), and 2s and 10s-treated Zn·Ph surfaces.

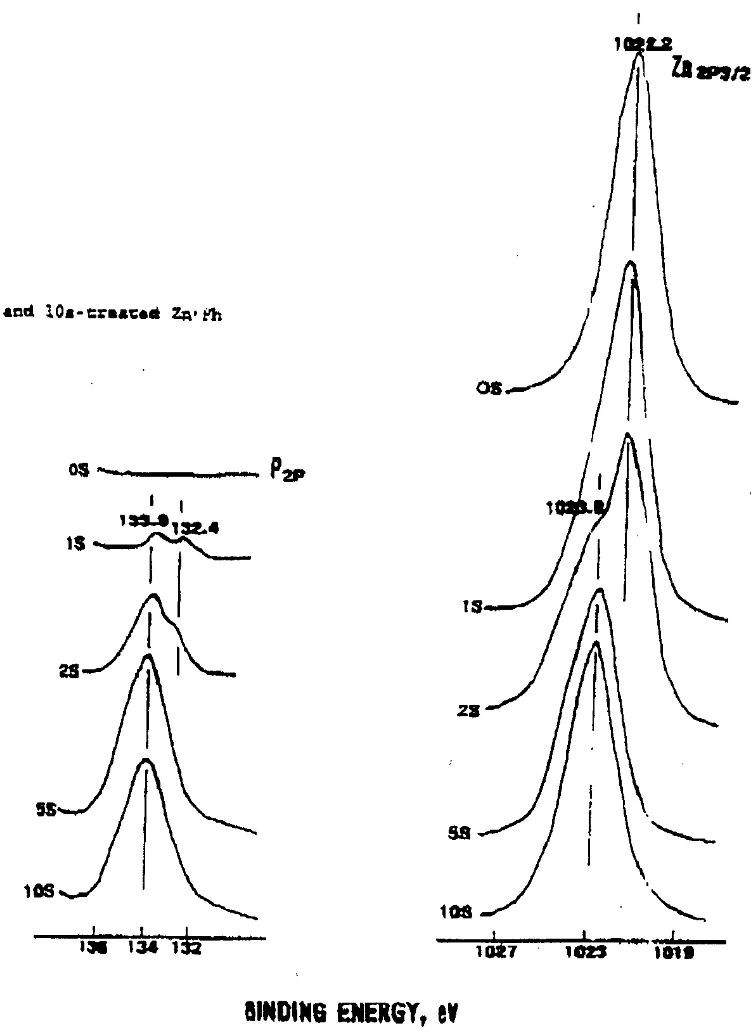

Figure 2. XPS P_{2p} and $Zn_{2p3/2}$ regions of Zn·Ph deposited on EGS as a function of immersion time.

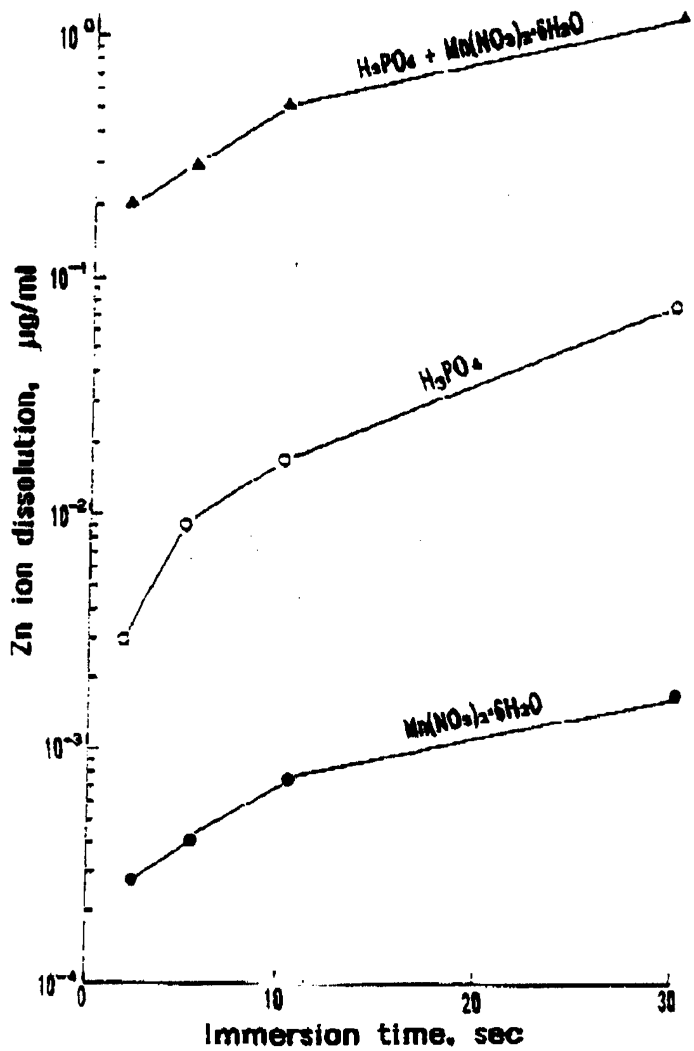

Figure 4. Changes in the concentration of zinc ions dissolved anodically from galvanized coating after immersion of ECS into H_3PO_4, $Mn(NO_3)_2 \cdot 6H_2O$, and $H_3PO_4 + Mn(NO_3)_2 \cdot 6H_2O$ solution, respectively, at 80°C.

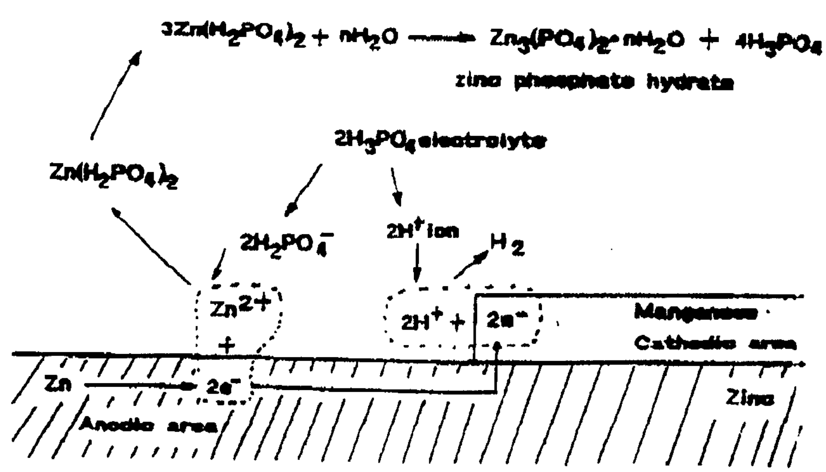

Figure 5. Hypothetical multiple reactions occurring at interfaces between ECS and Mn-incorporated H_3PO_4 electrolytes.

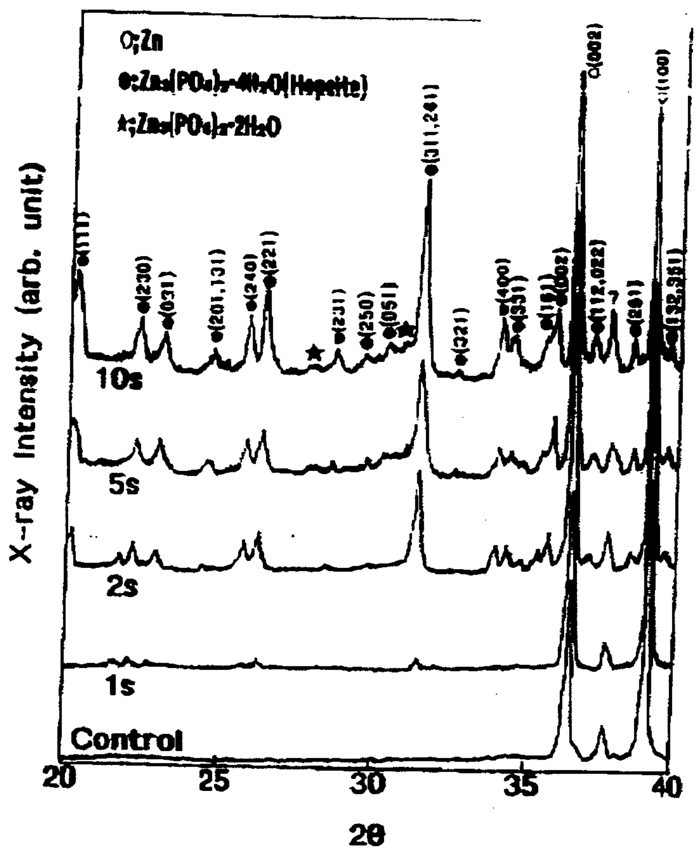

Figure 6. XRD patterns of "as-received" EGS surfaces as control, and Zn·Ph made after immersion for 1, 2, 5, and 10s.

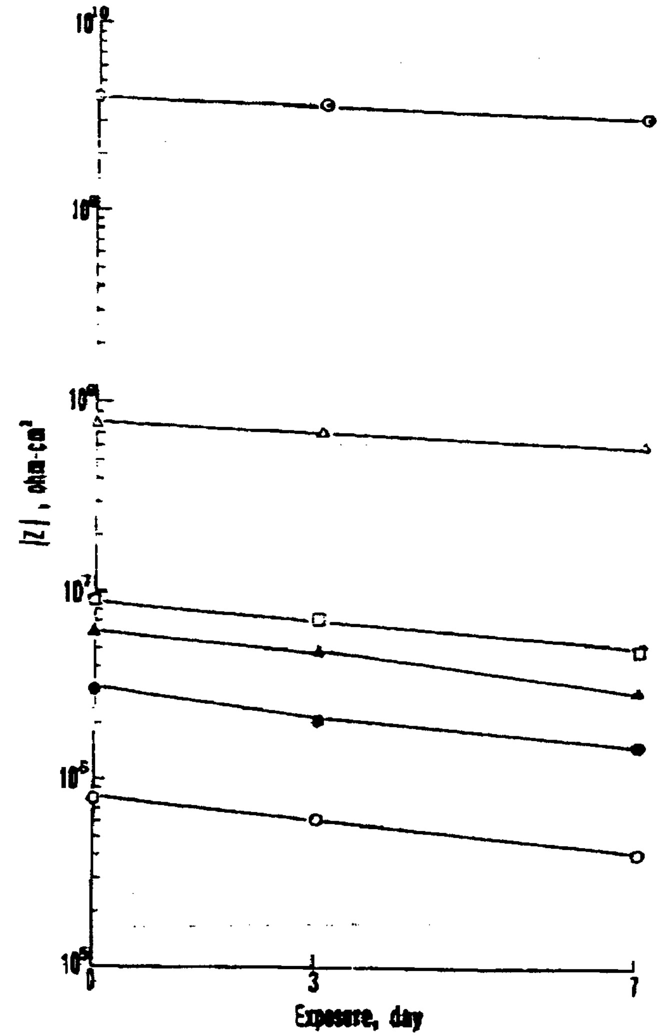

Figure 9. Changes in impedance value for (○) EDP-, (●) EDP/Zn·Ph-, (▲) EDP/p(AA)-Zn·Ph-, (□) EDP/APS-, (△) EDP/APS/Zn·Ph-, and (⊙) EDP/APS/p(AA)-Zn·Ph-coated EGS panels as a function of exposure time.

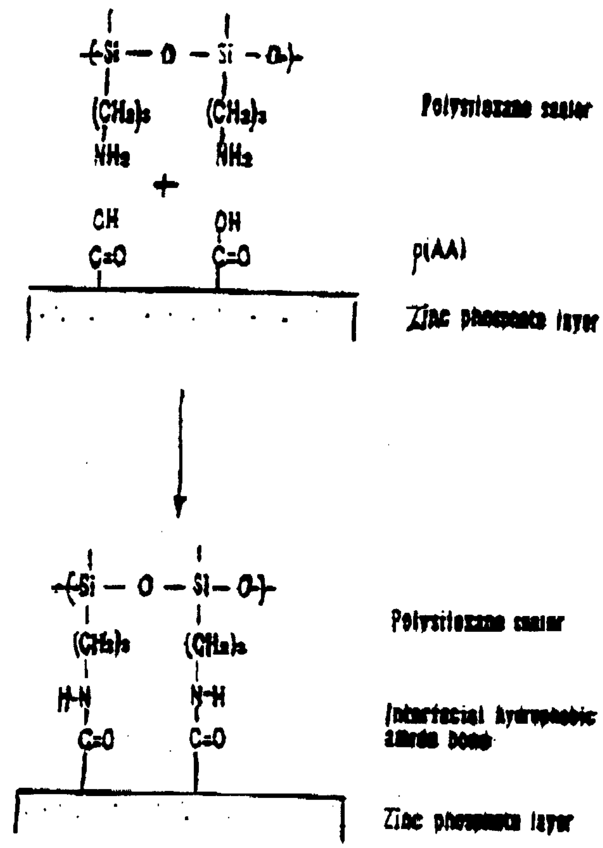

Figure A

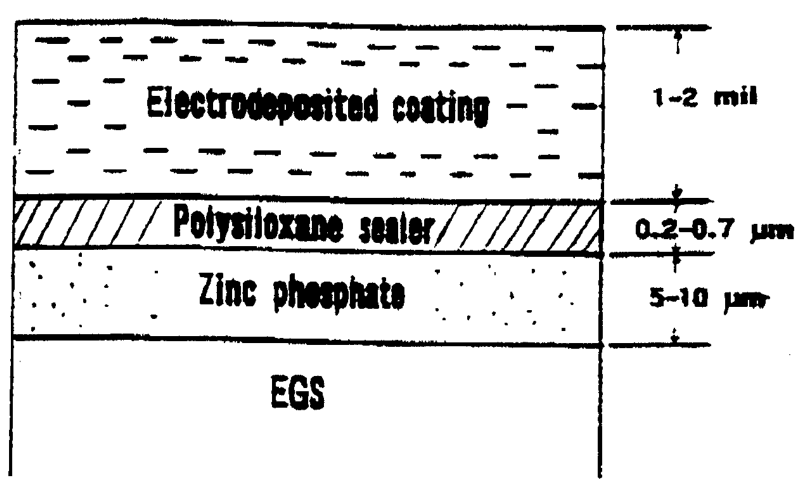

Figure B

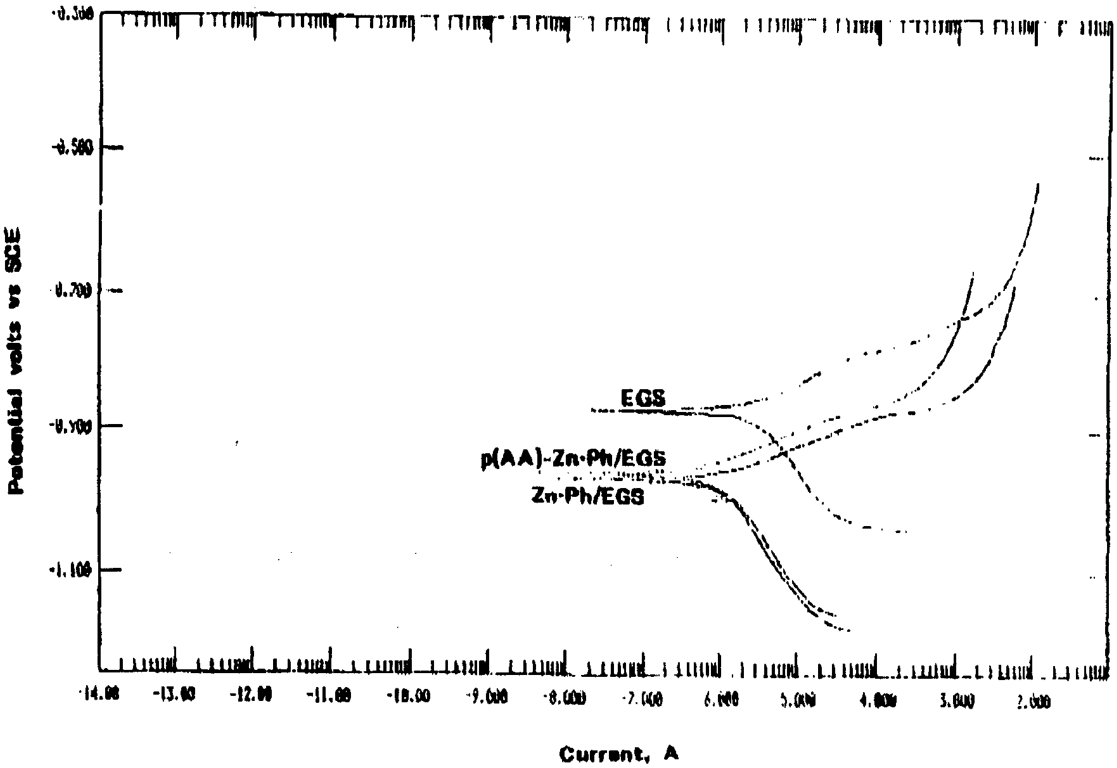

Figure 7. Polarization curves for "as-received" EGS, and p(AA)-modified and unmodified Zn·Ph coating panel

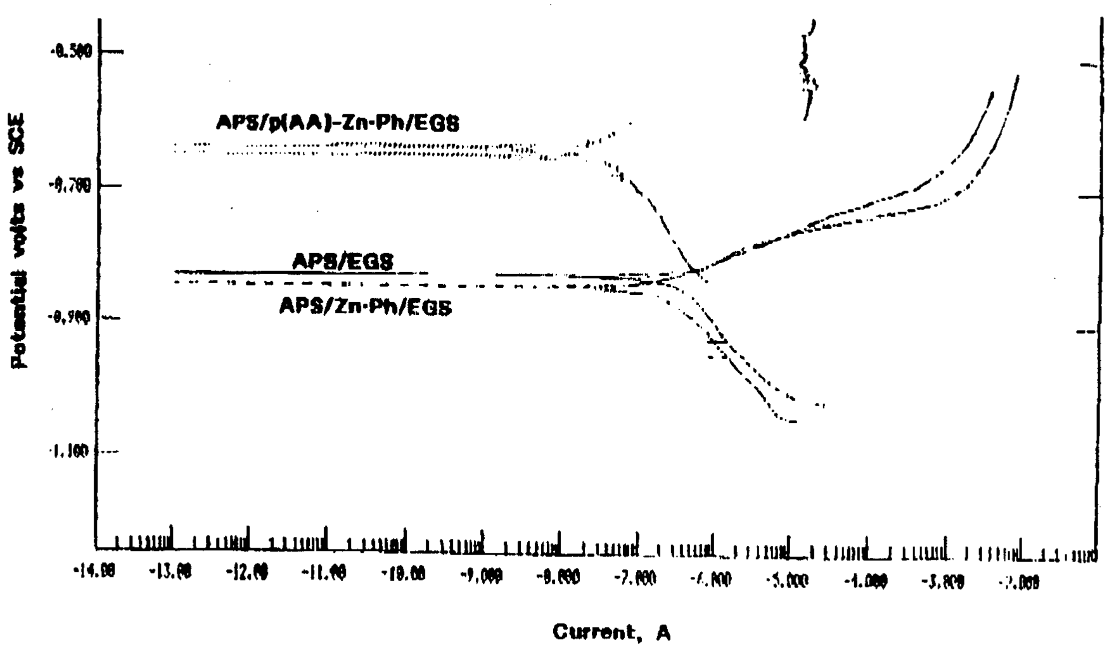

Figure 8. Polarization curves for the APS-sealed EGS, Zn·Ph, and p(AA)-Zn Ph panels.

On-Site Treatment of Wash Water at Arnold AFB Reduces Costly Disposal

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Annual Joint Services Pollution Prevention Conference & Exhibition, San Antonio, Texas, August 1998

This paper will describe a water treatment system designed to process wash water generated during propulsion wind tunnel (PWT) cleaning at Arnold Air Force Base. Following a brief discussion of the waste generating process, analytical results of an on-site pilot test will be reviewed. Integral components of the treatment system were selected based on the demonstrated success of the pilot test. In conclusion, the paper will detail the flow path of processed water from generation to final product and summarize projected operating costs.

Introduction

Arnold Air Force Base (AAFB), located in Middle Tennessee, is the site of Arnold Engineering Development Center (AEDC). AEDC is one of the nation's leading aerodynamic and propulsion research and test facilities. Maintaining a diverse array of test units including: propulsion wind tunnels, rocket and turbine engine test cells, space environmental chambers, high temperature arc heaters, and ballistic ranges in a clean and safe environment can pose unique challenges, especially when it comes to pollution prevention and waste minimization. Wash waters generated during propulsion wind tunnel (PWT) cleaning annually generate approximately 30,000 gallons of waste. Primary contaminants include dirt, grit, detergents, heavy metals, and both free and emulsified oils. In an effort to eliminate costly off-site disposal, a 400 gallon per hour waste water treatment system was designed and constructed to process the wash water prior to permitted release. Major processes incorporated into the system design include oil water separation, emulsion splitting and encapsulation, mechanical filtration, and advanced chemical oxidation. Figure 1 is a photograph of the combined treatment system.

Figure 1 – PWT Wash Water Treatment System

Wash Water Generation and Characterization

PWT 16T is a closed loop wind tunnel with a footprint of approximately 200 ft by 400 ft and diameter ranging from 36 ft to 55 ft. During the course of testing, oil is introduced from bearings, pump seals, and numerous hydraulic systems and their fugitive leaks. During maintenance and shutdown periods, cumulative contamination due to dust, paint, and dirt can contribute to environmental problems. This dirty environment can lead to both personnel safety (i.e., slip and fall hazards) and test related problems such as oil and grit build-up on test models. The only effective cleaning process to date includes:

a) Spraying a cleaner/degreaser on the tunnel walls
b) Allowing sufficient contact time (2-3 hours) on oil dried surfaces, and
c) Rinsing the walls to sufficiently remove the deposits and cleaner/degreaser

Resulting wash waters are collected at tunnel low points, rough screened, and drained into a 1,500 gallon polyethylene container to await characterization. Representative samples are collected from each tank by recirculating a minimum of three tank volumes and pulling samples from the flowing return stream. Collected samples are taken to the on-base chemistry laboratory and analyzed for metals per Method 1311 of SW-846, Toxicity Characteristic Leachate Procedures (TCLP). Other analyses such as pH, Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Volatile Organic Compounds (VOC), and Oil and Grease are periodically monitored.

The following studies show the degree of cleaning and subsequent contamination is largely dependent on the cleaner used. Over the years maintenance personnel have settled upon two cleaners, Cytra Klean and So-Pro. Cytra Klean is the preferred cleaner due to its adhesive action on the oily tunnel walls and degreasing ability. Cytra Klean detergent is comprised of citrus terpines (oils derived from the skins of citrus fruit, extracted during the process of concentrating). These light oils are the active ingredients in the cleaning action as well as the ingredients that create such a tight chemical emulsion.

Pilot Test Results

In September 1996, AEDC maintenance personnel cleaned representative PWT sections with both Cytra Klean and So-Pro cleaners. Approximately 1,500 gallons of each waste stream were collected. Within two weeks of waste generation, a full-scale, on-site pilot test was conducted to evaluate the effectiveness of emulsion splitting encapsulation and advanced chemical oxidation (ACO) on the removal of contaminants from tunnel cleaning waste. These processes are outlined in a proceeding section. Representative samples were obtained of each tank and the analytical results are summarized in columns 2 and 7 of Table 1. Both wet and dry sludge samples were analyzed and are tabulated in columns 5, 10 and 11. Note in most cases, sludge TCLP results were well below influent wash water TCLP concentrations. One sample was obtained to characterize the emulsion splitting encapsulation system discharge prior to further conditioning. This data, summarized in column 8, demonstrated a significant improvement in water quality (99.5% improvement for oil & grease, and >85% for lead). Samples were taken at various times during recirculation through the ACO system. These samples are summarized in columns 3, 4, and 9. This data demonstrates a significant overall improvement in water quality with a minimum recirculation time of 8 hours (approximately 3 to 4 tank volumes).

Table 1 - Analytical Data

1	2	3	4	5	6	7	8	9	10	11
Description	So-Pro Waste H2O	Finish H2O at 8hr	Finish H2O at 24hr	Dry Filter Cake		Cytra Klean waste H20	Outlet of VA-2000	Finish H2O at 12hr	Dry Filter Cake	Wet Filter Cake
pH (pH units)	7.96	7.85	8.3			7.6	7.6	4.5		
Turbidity (NTU)	560	7	6			19,000	9			
TSS (ppm)	441	14.6	7.5			1498	26	7		
TDS (ppm)	1420	2086	1700			2556	3194	6205		
Oil & Grease (ppm)	28.2	0.4	<0.2			8835	48	0.6		
Metals - Total (ppm)										
As		<0.07	<0.07				<0.7	0.09		
Ba		<0.001	<0.001				0.04	0.02		
Cd		<0.002	<0.002				0.04	<0.002		
Cr		<0.01	<0.01				<0.10	0.03		
Pb		0.05	0.07				<0.40	<0.02		
Se		<0.01	<0.01				<1.0	<0.02		
Ag		0.008	0.007				0.08	<0.02		
Metals - TCLP (ppm)										
As	<0.070	<0.07		<0.14		<0.07	<0.7	0.09	<0.07	<0.14
Ba	0.04	0.002		0.13		0.7	0.01	0.02	0.14	0.19
Cd	0.09	<0.002		0.03		0.54	0.03	<0.002	0.15	0.15
Cr	0.26	<0.01		<0.02		0.38	<0.10	0.03	0.02	0.02
Pb	1.23	<0.04		<0.08		2.85	<0.40	<0.02	<0.04	0.41
Se	<1.0	<0.10		<0.20		<1.0	<1.0	<0.02	<0.10	<0.20
Ag	<0.05	<0.005		<0.01		0.03	0.1	<0.02	<0.005	<0.01

Results shown in column 9 reflect water processed through a multi-media filter at the vendor laboratory. The purification loop booster pump was undersized and could not pump the processed (Cytra Klean) water through the multi-media filter. The vendor reported that tank corrosion during transport and storage, prior to processing, was probably responsible for the large increase in TDS.

The system, as tested, was a fully automated 500 gallons per hour batch treatment system. The system was primarily operated in the manual mode to determine processing times for the two streams tested. Table 2 is a summary of operational data and consumable material usage.

Table 2 - Summary of Operational Data and Consumable Use

Detergent Type	Process Time (min)	Encapsulant Usage (g/gal)	Filter Paper Usage (yards)	Gallons Processed
So-Pro	23	23	3	1500
Cytra Klean	39	30	15	1500
Combined Average/Totals		**27**	**9**	**3000**

Note the additional processing time and encapsulant usage for Cytra Klean laden wash water. This factor along with redundancy afforded by a backup system and additional storage led to the design of two separate influent receiving and process water storage tanks. Table 3 is a summary of processing costs based upon gallons processed (3,000 gallons) and consumables expended.

Table 3 - Cost per Gallon (Excluding Manpower Requirements)

Detergent Type	Encapsulant Amount (lb)	Encapsulant Cost ($/lb)	Cost per Gallon (¢)
So-Pro	75	$2.^{35}	12¢
Cytra Klean	100	$2.^{35}	16¢

Process Description - Unloading

Wash water is transported to the treatment system and unloaded via an air operated diaphragm pump. A diaphragm pump was selected to minimize further emulsion of settled wash water. Two 2,000-gallon internal conical tanks constructed of high-density polyethylene (HDPE) are used to store the wash water prior to treatment. Internal conical construction eliminates the need for external support stands saving space, reducing maintenance requirements, and enhancing cleanout of collected solids. Chemical and mechanical emulsions may, over time, separate from the aqueous phase. This separation is caused by the lighter specific gravity of some contaminants (i.e., oils, citrus-based cleaners, etc.) vs. water. Each tank is equipped with a surface mounted belt skimmer to collect these contaminants for reuse, recycling, and/or disposal.

Process Description – Pre-Filtration

A fully automated emulsion splitting encapsulation system based on the physical-chemical treatment process[1] is employed as both a pre-filter and primary treatment. Emulsion splitting, coagulation, flocculation, adsorption, waste encapsulation and solidification of resultant sludge are all employed during this process. Wash water from the selected tank is transferred, level controlled to the treatment reactor. After a brief mixing period, an auger feeds the desired amount of emulsion splitting agent (flocculent) to the reactor volume. The amount of splitting agent added is fully adjustable based on user knowledge of a particular waste stream or jar testing results.

The reaction of wash water/splitting agent mixture is hydrodynamically promoted by a variable speed mixer allowing dispersed (i.e., turbid particles, metals, oil drops, etc.) and dissolved noxious matters (i.e., tensides, water soluble solvents, emulgated hydrocarbons, etc.) to agglomerate and form a microfloc. These flocs continue to join, bridging from one surface to another and binding the individual particles into larger agglomerates called macrofloc. Flocculation is promoted by slow mixing. A high mixing velocity can shear the floc, reintroducing contaminants into the wash water. Rarely do sheared floc re-form to their optimum size and strength. Not only does flocculation increase the size of the particle but also affects the physical nature as well. Sludges and slurries, when flocculated, dewater at faster rates because of the less gelatinous structure of the floc. [2]

After flocculation is optimized, mixing is stopped and a sedimentation period allows the floc to settle in the reactor. There are three stratified layers in the reactivation vessel. The top layer consists primarily of clean water but may contain floating solids (i.e., undissolved clay, plastic, etc.) and free oils in heavily contaminated water or if an excessive quantity of flocculant was added. The middle layer contains cleaned water (clear well) and is the desired product. The bottom layer is the resulting sludge and possible end use of this material will be discussed later in this section. Water in the clear well is pumped through a 25-micron filter to one of two 2,000-gallon process water storage tanks. Based on analytical results, the processed water can be reused, discharged to a permitted outfall, or retained for additional treatment.

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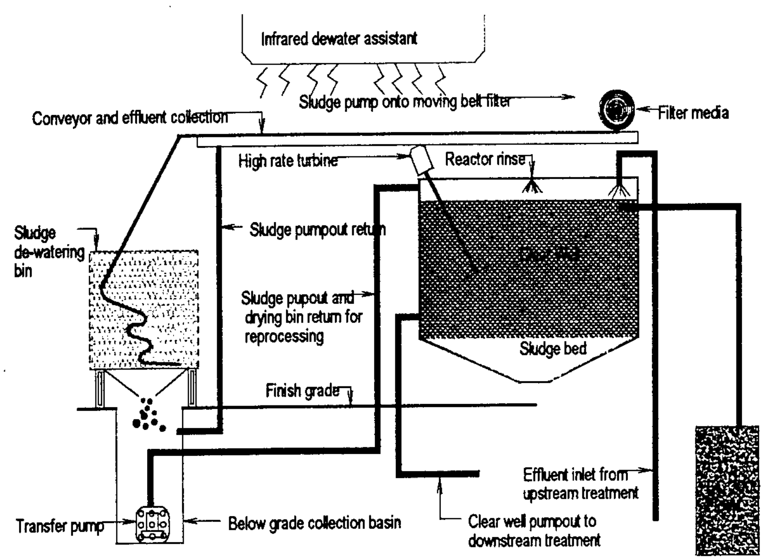
[1] The Nalco Water Handbook describes Physical-Chemical treatment as a process by which waste effluent is taken into a rapid mix and flocculation zone where a large dose of chemicals is added to produce a massive chemical coagulation and flocculation. Nalco Water Handbook, second edition, copyright 1988. McGraw-Hill Inc.

[2] Flocculation section of the Nalco Water Handbook referenced above.

The sludge layer, containing encapsulated contaminants, is pumped onto a moving belt particulate filter for de-watering. As sludge accumulates on the filter belt, the belt automatically advances exposing new filter paper. Filtered water gravity drains to a de-watering sump and is pumped back into the original storage tank for reprocessing. Filter paper and sludge are sent to a bin for further de-watering. An infrared heater is mounted above the de-watering bin to assist in the process. De-watered solution gravity drains to a sump and is pumped back to the original storage tank for reprocessing. The de-watering bin is forklift accessible and self-dumping with a volume of approximately 2 cubic yards. Approximately 8,000 to 10,000 gallons of water can be processed before the bin is full. A national concrete/masonry company is currently evaluating the resulting sludge as a potential aggregate to their brick making process. Figure 3 is a schematic representation of the emulsion splitting process.

Figure 3 – Emulsion-Splitting Encapsulation Pre-Filter



Process Description – Post Treatment

Final treatment is available to water stored in the process water storage tanks. Advanced Chemical Oxidation (ACO) and mechanical filtration were selected for this purpose. ACO is a group of processes utilizing ultra-violet (UV) light with catalyst oxidizers hydrogen peroxide and ozone to precipitate dissolved metals and oxidize organic contaminants to carbon dioxide and water. The following excerpt provides an excellent summary of this process. "UV light catalyzes the chemical oxidation of organic contaminants in water by its combined effect upon the organic substances and reaction with hydrogen peroxide. First, many organic contaminants that absorb UV light may undergo a change in their chemical structure or may become more reactive with chemical oxidants. Second, and more importantly, UV light catalyzes the breakdown of hydrogen peroxide to produce hydroxyl radicals, which are powerful chemical oxidants. Hydroxyl radicals react with organic contaminants, destroying them and producing

harmless carbon dioxide, halides, and water by-products. The process produces no hazardous by-products or air emissions."[3]

Two multi-stage filters are installed upstream of the UV lamp to provide maximum penetration of UV light through the water. This penetration is critical to gain full advantage of bond destruction by direct photolysis. Any remaining waterborne impurities (i.e., turbidity, TDS, foaming, etc.) reduce absorption of UV radiation by the treated water and lower the hydroxyl radical production. Each multi-stage filter consists of a coalescing media, 25 micron poly spun fiber filter, 400 cubic inches of activated carbon, and a hydrocarbon purge (vent).

Operation & Maintenance Costs

While the treatment system is fully automated, it's the author's opinion that at least one dedicated/qualified waste water treatment plant operator will be required to operate or ensure smooth operation of the system. AEDC plans to operate the system with existing personnel and expects no additional staffing requirements. A schedule of estimated operation & maintenance costs are listed in Table 4. These include annualized costs of consumable supplies, operation and maintenance personnel, and a maintenance contract (optional). Utility costs are excluded.

Table 4 - Annualized Operation & Maintenance Costs[4]

Description	Units Required	Unit of Issue	Frequency of Replacement	Cost per Unit	Annual Cost
Operating Supplies					
Hydrogen Peroxide	12	55 gal	Monthly	$217.50	$2,610.00
Flocculant / Encapsulant	36	50 lb	As needed	$117.34	$4,224.00
Filter Paper	8	Roll	As needed	$175.00	$1,400.00
Operation and Maintenance Personnel					
Operations	75	hrs	N/A	$30.00/hr	$2,250.00
Maintenance	75	hrs	N/A	$30.00/hr	$2,250.00
Maintenance Contract - Optional					
Vendor	1	ea	Monthly	$2160.00	$2,160.00
				Total Annualized Operations & Maintenance Costs	**$12,734.00**
				Total Cost per Gallon (30,000 gallon production rate)	**42¢**

At present, the approximate cost to dispose of non-hazardous waste is 60¢ per gallon. This amounts to cost savings of approximately $7,000 per year based on a waste generation rate of 30,000 gallons. The system is presently undergoing performance verification and it is projected that existing capabilities will be diverse enough to treat an additional 70,000 gallons of AEDC generated non-hazardous waste at a comparable cost. This would increase the annual cost savings to over $20,000 per year.

[3] Quote captured from the "Peroxide Advanced Oxidation Wastewater Treatment" article downloaded from the Envirosense Internet web site at HTTP://clean.rti.org

[4] Annualized cost based upon a 30,000 gallon per year production rate.

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Laser Cleaning for Pollution Prevention

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Abstract

The use of lasers to perform surface cleaning tasks is currently being investigated as a new alternative to traditional solvent and aqueous cleaning approaches for removal of contamination. Laser cleaning removes contaminants rapidly and directly with no cleaning

Aðagent@ð or secondary waste stream, thus minimizing waste disposal costs. It is particularly appropriate for precision cleaning operations where laser removal of contaminants to <2 mðg/cm2 has been demonstrated with short pulse Nd:YAG lasers. A review of current cleaning operations that may be suitable for laser cleaning technologies is presented. These operations include removal of oils and greases, adhesives, conformal coatings, and paint. A primary target application of the technology is preparation of surfaces for coating or bonding, but several niche applications such as preparation of circuit boards for repair may benefit. Physical mechanisms associated with different modes of contaminant removal are discussed and recent laser cleaning data acquired for some of these modes are presented. The results suggest that very compact, portable laser cleaning systems can be built employing hand-held laser cleaning end-effectors for fiber-optic delivered beams. Prototype laser cleaning system hardware is described briefly and scalability of laser technologies to meet several cleaning requirements will be summarized.

Introduction

Traditional methods of removal of organic contaminants and particles from metal surfaces in precision cleaning operations have employed cleaning agents such as chlorofluorocarbons (CFC=ðs) and other solvents that are now recognized as harmful to the environment or workers. Exposure of contaminated surfaces to laser beams with a sweep gas to carry away the effluent material ejected from the surface offers the potential for precision cleaning without any cleaning agent or secondary waste stream. For more than twenty years, researchers have been investigating the use of lasers to clean many contaminant or coating types from a variety of surfaces in applications ranging from art restoration,1 surface decontamination,2 and paint stripping,3,4 to surface bond preparation,5 wire insulation stripping,6 and optics cleaning.7 In recent years, extensive efforts have been devoted to research on laser removal of particulates from surfaces in the semiconductor and magnetic media manufacturing industries.8-10 Only very recently has much research been devoted to the removal of oils and greases from metal surfaces.11-14 This work demonstrated for the first time that precision cleaning goals (organic residue <
2
mðg/cm2) could be achieved in an open work environment without solvents or cleaning agents.

Cleaning surfaces with laser beams offers several advantages over use of conventional solvent and aqueous methods. Laser beam pulses are delivered to the surface in a simple one-step operation in which the contaminant is ejected into an effluent removal sweep gas. There are no cleaning agents to purchase, handle, store, recover, nor recycle and no heating, spraying, nor washing chambers/baths. The contaminant comes out in a minimally compact form for disposal (no secondary waste stream to process). The laser cleaning process is relatively fast, with area coverage rate limited only by average laser power available. There are no soak times nor drying times to be considered. The laser cleaning beam can be delivered remotely by fiber optics to provide the flexibility required for hand-held spot cleaning applications (e.g., flight line maintenance of aircraft). The nature of laser cleaning is such that precise areas can be processed without affecting adjacent areas, with the location precision limited only by the motion control methods employed. Laser cleaning is particularly appropriate for removing adherent coatings that otherwise require long soak times in harsh solvents, e.g. cured epoxy. On the other hand, laser cleaning is a line-of-sight technique and cannot easily get to soils in crevices or small enclosed volumes such as might occur in degreasing large numbers of intricate parts. The following sections provide preliminary information on those applications which may benefit from laser cleaning and on hardware approaches to implementing laser cleaning.

Potential Laser Cleaning Application Areas

A survey of aerospace cleaning requirements was undertaken to find areas where laser cleaning technology might contribute to pollution prevention in aircraft maintenance depot operations. These applications are discussed below along with the mechanism of contaminant removal by pulsed laser beams.

Removal of Oils and Greases

In many maintenance operations, solvent wiping has been used to clean oils, greases, and smut from surfaces. While widely used, the technique is polluting and does not always produce a known surface cleanliness level. Laser cleaning may be a useful replacement for solvent wiping in certain applications requiring cleaning to a low level of organic residue on the surface. An example of this type of operation is preparation of an aluminum-aircraft-skin crack area for composite patch repair. In the present approach, after the surface has been abraded to enhance adhesion of the bond layers, a solvent such as 2-butanol (MEK) is used to clean particles and organic residues from the surface. Scanning the area with a pulsed laser beam of appropriate intensity instead of solvent wiping will remove the abrasive grit, oil contaminants, and loosely attached aluminum particles created by the abrasion process. The result is a precision cleaned aluminum surface that should have good adhesive properties. No damage to the aluminum substrate occurs, because the laser pulses are sufficiently short that the heat absorbed has little time to conduct very far into the metal (about 1

mðm for a 16-ns pulse).

The mechanism of removal of oil and grease contaminants from metal surfaces by short laser pulses is still under investigation, but is thought to be a thermo-mechanical effect wherein the laser beam passes through the contaminant film (for visible and near infrared laser beam wavelengths), is partially absorbed by the metal, and ejects the contaminant as an aerosol by vaporization or shock expansion of a small amount of material at the contaminant/metal interface.[14]

Another example where laser cleaning may be useful is preparation of small areas of aircraft skin for touch-up painting. In this case, the area to be cleaned may have primed or painted regions in addition to metal area covered with contaminants such as hydraulic fluid. The metal areas are cleaned by the mechanism discussed above. The primed or painted areas can also be cleaned by a similar mechanism, however, the paint typically absorbs a higher fraction of the incident laser beam pulse and, therefore, lower beam energy per unit area (fluence) is required to achieve the same contaminant ejection effect.

Removal of Adhesives, Sealants, and Transparent Coatings

In earlier work,[11] it was discovered that cured epoxy resin patches bonded to stainless steel could be easily removed with laser pulses in a simple Aðdebonding@ð process. In this case, the laser beam passes through the semi-transparent epoxy layer and is absorbed in the substrate metal. In one pulse the bond interface is opened as evidenced by light scattered from the gap created. The mechanism of breaking the bond is believed to be either a shearing stress from differential thermal expansion or shocks from vaporization of small quantities of interface material. After an area is scanned with overlapping pulses to create a continuous gap at the interface, the epoxy lifts off the surface in one piece for simple disposal.

In surveying potential applications of laser cleaning, it was found that there are other instances where it is of interest to remove transparent or semi-transparent coatings from surfaces. In repair of printed wiring assemblies, it is necessary to remove conformal coatings prior to removal and replacement of an individual component identified as defective. Conventional approaches entail either a solvent soak which removes the entire coating or local abrasion of the coating by various methods which may damage the assembly. By using the laser debonding mechanism, the coating can be removed over the solder pads or components of interest in a relatively quick clean operation. Another possible application is removal of sealant material from metal surfaces. In this case, the coating may have pigmentation which will inhibit the penetration of laser light to the substrate surface and the debonding mechanism will be complicated by absorption in the sealant.

Removal of Paint Coatings

There is a widespread need for environmentally friendly means of removing paint coatings. Lasers have been under investigation for several years[3,4] for this application and paint

removal systems have generally employed CO2 lasers sized for large area decoating of surfaces. This wavelength of laser (10.6 mðm) is not well-suited for fiber optic delivery and remote or hand-held beam delivery is complex. The survey of applications suggested that there are some small-area paint removal requirements (such as detailing around masked areas) that would benefit from a compact hand-held beam delivery system such as those possible with the Nd:YAG laser (1.06 mðm). While very little paint removal research has been performed with YAG lasers, effective removal may be anticipated by ablation and thermal shock mechanisms. Paints typically contain heavy loadings of pigments which cause the laser beam to be absorbed over very short distances compared to the coating thickness. The paint heats and ablates layer by layer as pulses are applied to the surface. For short pulses that are possible with Nd:YAG lasers (10 ns), thermo-mechanical effects may enhance paint removal rates.

The applications outlined above are representative of a wide variety of needs for solvent-free cleaning approaches. Preliminary testing of the laser cleaning process on materials specific to these applications has just begun and selected test results are presented below.

Preliminary Test Results

A summary of the results of preliminary testing of laser cleaning techniques is given in Table 1. These tests were conducted on a few samples representative of the potential applications identified in the survey. Test coupons (1-inch by 2.25-inch) were exposed to a uniform fluence flat-top laser beam from a fiber-optic end-effector receiving pulses from a Nd:YAG laser (16-25 ns pulse width, 1.06 mðm wavelength, 20 Hz repetition rate). The coupons were scanned under the stationary beam with a computer-controlled motorized stage. Additional testing will be required to qualify the laser cleaning process for a given application that looks promising. The laser cleaning of sanded and grit-blasted aluminum for bond preparation was successful to the level of measurement available. More than three times the amount of grit and loose aluminum was removed with the laser than with a simple dry wipe at a pulse fluence of 1150 mJ/cm2. When the sample was contaminated with hydraulic fluid, this, too, was removed in the laser process. While bonding trials will be required to validate the laser approach, it is anticipated that the precision cleaning level achieved in laser cleaning of metals14 will be sufficient for good bonding. When painted metal was contaminated with hydraulic fluid at a gross contamination level (2000

mðg/cm2), the fluid was removed in four passes at a relatively low pulse fluence of 290 mJ/cm2. Higher fluences should remove the fluid from the sample in one pass.

The removal of silicone and polyurethane conformal coatings from a solder surface was straightforward as expected, based on the previous data for removal of epoxy from metal. The coatings debonded from the metal surface in one pulse and scanning generated a continuous debonding gap in the area scanned. The coating was broken away from the edges of the area debonded by the laser by brushing with a plastic bristle brush. These coatings are fairly difficult to remove by alternative cleaning methods.

The removal of a 3.7 mil thick layer of MIL Spec paint (MIL-P-85582/MIL-C-85285) was accomplished effectively using the scanned pulsed laser beam. While paint removal was measured for a wide range of fluences, the most efficient removal was achieved for pulse fluences above 2000 mJ/cm2, where the effective heat of removal was about 3 kJ/g. The reduced fluence for removal was about 10 J/cm2/mil which is much less than that observed for pulsed CO2 laser beams. The effluent plume contained a considerable amount of paint particles which confirms that thermal shocking is occurring in addition to simple ablation. This result has also been observed by Liu and Garmire15 who used Nd:YAG pulses to remove thin acrylic paint coatings from surfaces.

Laser Cleaning Equipment

Implementation of laser cleaning in routine maintenance operations will require the development of custom compact hardware that is easy to use and accomplishes the target cleaning task reliably. The most likely form of a laser cleaning system for small-area cleaning tasks as outlined above will be a stand-alone cabinet with an umbilical connection to a remotely operated hand-held cleaning head. In form and operation, it will be similar to a vacuum cleaner with a hose connected cleaning tool. The cabinet will house a laser beam generator, beam conditioning optics, effluent control system, interface electronics, and a system controller. The umbilical cable will contain the beam delivery fiber optics, hoses for inlet and outlet effluent control gas flow, and electrical control wiring. The hand-held end-effector will contain optics for delivery of the beam to a surface, gas flow nozzles, sensors, and operator controls and indicators. This generic approach can be scaled within reason over a range of applications with different laser power requirements. For example, the smallest system might be for conformal coating removal where only an occasional pulse or two might be required to debond coating over a solder pad or component (1 W laser power). In this case, an external vacuum system might remove the effluent. At the other end of the small-area processing spectrum, might be the paint removal application, where removal rates are more critical. The laser cleaning technique is linearly scalable in the sense that area coverage rates are proportional to average laser power. As an example, consider the power required to remove 1 ft2 (929 cm2) of paint (0.0037-inch thick) in a critical area not processed by alternative methods. Using a value of 10 J/cm2/mil, the total beam energy required is 34.4 kJ. If 12 minutes can be allotted to the task, the average laser power required is 48 watts. Higher laser powers would permit faster removal rates. It should be noted that the entire paint removal task is completed in the 12 minutes since there is no surface preparation nor residue cleanup.

Table 1. Summary of preliminary test results.

Sample Type Fluence per Pulse (mJ/cm2) Comment
7075 T-6 Clad Al abraded with 320 grit aluminum oxide paper or 27
mδm grit blast; dry
wiped
1150
Surface cleaned of grit and loosely held aluminum in one pass*

7075 T-6 Clad Al abraded with 320 grit aluminum oxide paper or 27 mδm grit blast; contaminated with 20-25 mδg/cm2 hydraulic fluid
1150
Surface cleaned of grit, loosely held aluminum, and hydraulic fluid in one pass

Grey painted 2024 T-3 Al (MIL-P-85582/MIL-C-85285), 3.7 mils thick; contaminated with 2000 mδg/cm2 hydraulic fluid
290

Surface cleaned of hydraulic fluid in four passes
MS-460A Silicone Conformal Coating on solder (3 coats)
750
Debonded coating in one pass; removed from edge attachment with brush
MS-470N Urethane Conformal Coating on solder (3 coats)
750
Debonded coating in one pass; removed from edge attachment with brush
Grey painted 2024 T-3 Al (MIL-P-85582/MIL-C-85285), 3.7 mils thick
2360
Paint coating removed in two passes * 7.6 pulses per pass

Conclusions

The preliminary results of laser cleaning research on practical aerospace cleaning problems suggest that there are several areas where pulsed laser technology may make a contribution to pollution prevention through reduced use of solvents. Areas showing promise for the introduction of laser cleaning technology include preparation of surfaces for adhesive bonding and for touch-up painting, removal of conformal coatings, and removal of paint in critical small-area detailing.

Acknowledgments

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Environmentally Preferred Alternatives to Methylene Chloride for Paint Stripping

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ABSTRACT

Chemical strippers (e.g., methylene chloride) traditionally have been used to remove paints and coatings. These chemical strippers have many advantages but they are potentially harmful to worker health and safety and the environment. Additionally, compliance with future clean air regulations (NESHAP) may make their use very costly.

In response to an ESOH Technology Need Survey conducted by the Human Systems Center (HSC/XRE), the Air Force Research Laboratory evaluated environmentally preferred chemical alternatives for methylene chloride based chemical paint strippers to address a need submitted by the Ogden Air Logistic Center (OO-ALC) Commodities Directorate, Landing Gear Division located at Hill AFB. ARFL initiated and completed the identification and evaluation project for a commercially available, environmentally friendly, method of removing the paint from aircraft landing gear. Although mechanical paint stripping technologies are the preferred pollution prevention practice to replace chemical paint strippers; the complex geometry of the landing gear components required that environmentally friendly chemical paint strippers be investigated as a potential "drop-in" replacement for OO-ALC and other Air Force applications. The study concluded that an environmentally friendly alternative chemical paint stripper is currently available to meet OO-ALC's need (Ecolink SAFE-STRIP). The addition of recommended process improvements combined with the material substitution will increase the efficiency of OO-ALC's operation and will provide an economically feasible while further reducing environmental impacts.

INTRODUCTION

This is a case study of how a replacement solution for phenolic methylene chloride was identified and evaluated using an eight step process.

The study was limited to dip tank/immersion paint stripping processes in use at OO-ALC. Therefore, the findings presented below are not directly transferable to other types of applications, although the steps used to identify and evaluate the alternatives can be applied to any material substitution.

The following eight step process was used.

- Step 1 - Determine the Process Boundaries
- Step 2 - Identify Potential Commercial-Off-The-Shelf (COTS) Alternatives
- Step 3 - Down-select the Field to the Top 10 Alternatives
- Step 4 - Evaluate the Technical Performance of the Selected Alternatives
- Step 5 - Compare the Best Alternative to the Current Process for Environmental Impacts and Cost Benefit Analysis
- Step 6 - Identify Process Improvements
- Step 7 - Evaluate Best Alternative with Potential Process Improvements
- Step 8 - Implement or Recommend Alternative Course of Action

Step 1 - Determine the Process Boundaries

Process boundaries are defined as the material compatibility requirements, maximum processing time, quality requirements, existing process equipment, and environmental health and safety constraints. The process boundaries surrounding OO-ALC's operation set the focus and direction for the remaining steps. At OO-ALC the nature of the work determined that all potential alternatives must be compatible with aluminum, stainless steel, and magnesium; remove a minimum of 80% the paint within 30 minutes; and be suitable for use in a dip tank. In addition, the paint remover could not contain phenol, phenol derivatives, or chlorinated solvents which would have an adverse effect on the health of facility personnel.

Secondary process considerations where also determined to have a tangible cause and effect relationship on the overall operation. For example the methylene chloride tanks are currently operated at room temperature (cold). If the alternative paint stripper must be heated to work effectively, then heating elements must be used in the dip tanks. In addition, the air emissions from the alternative paint strippers could potentially rise faster then the methylene chloride stripper bypassing the air pollution control equipment and causing potentially high levels of worker exposure, maintenance problems with overhead equipment, and regulatory concerns. Boundaries must be defined to understand the scope or "universe" of the research effort conducted to identify potential alternative paint strippers.

Step 2 - Identify Potential Commercial-Off-The-Shelf (COTS) Alternatives

If vendors are selected randomly, companies with potential solutions may be easily overlooked, especially smaller companies. This may force additional expensive laboratory testing to be repeated because all randomly identified solutions failed to meet the final testing requirements. Thorough identification of all potential alternatives can greatly reduce the risk of repeating a project, even if all identified solutions fail, because the defined universe of vendors were all investigated.

For OO-ALC's landing gear paint stripping operation three sources of information were identified and used to define the "universe" of chemical paint stripper manufacturers: Department of the Air Force, Military Qualified Products List Under Military Specification MIL-R-83936B, "Remover, Paint, Tank Type: For Aircraft Wheels, Landing Gear Components and Other Aircraft and AGE Components;" WWW BigBook Yellow Pages on the Internet; and the Tri-Services Pollution Prevention Technical Library, Paint Removal, listed on the EPA's Enviro$ense home page on the Internet. Collectively, 142 unique vendors were identified. These three sources were considered comprehensive enough to validate a non-discriminatory selection process. Vendors were contacted by telephone and interviewed to obtain product information and determine product applicability to OO-ALC's process boundaries (e.g., designed for use in a dip tank).

Step 3 - Down-select the Field to the Top 10 Alternatives

Financial constraints restricted the research effort from conducting detailed product evaluations and laboratory testing of all alternatives identified. Therefore, selection criteria ranging from broad in nature to more restrictive were necessary to limit the field of alternatives.

Two levels of selection criteria were used to down-select the list of identified alternatives for OO-ALC from 142 unique vendors to the top 10 alternatives. The "first-cut" selection criteria was broad in nature and based on the primary process boundaries identified in Step 1. After the "first-cut" only 14 alternatives met the selection criteria and were chosen for further (level 2) evaluation and comparison ranking. The following four criteria were used to rank the 14 products based on the primary and secondary process boundaries identified in Step 1.

- *Regulatory and Environmental Policy Drivers* - Quantified by percent of total composition: NESHAP, EPA 17 Chemicals, ODC, SARA III, and AFMC 24.
- *Physical Characteristics* - Flash Point, Vapor Density, VOC Content, Specific Gravity, pH, and Viscosity.
- *Occupational Safety and Health* - Health Hazard (Acute & Chronic), Carcinogenicity (NTP, IARC, OSHA), Exposure Limit (ACGIH TLV, OSHA PEL), and PPE Required.
- *Economic/Process Factors* - Cost per Gallon, Estimated Longevity, Recyclability, Tank Type (Hot or Cold), Dwell Time, and Paint Residue (Small Pieces or Large Sheets).

Point values were assigned to each area and weighted equally to rank the 14 alternatives. The current phenolic methylene chloride paint stripper was also evaluated to bench mark the ranking. The ten alternative paint strippers with the highest scores were selected for laboratory testing. The top 10 alternatives selected and the control are listed in Table 1.

Step 4 - Evaluate the Technical Performance of the Selected Alternatives

Validating the material compatibility and performance characteristics of an alternative prior to full-scale implementation into the process can prevent serious damage to expensive parts and processing equipment, as well as, limit the capital purchase cost of the alternative product for testing. Laboratory testing can be effectively used with metal coupons to "roughly" simulate process demands.

For OO-ALC the top ten alternative paint strippers were tested in a laboratory using metal coupons and condemned aluminum aircraft wheel segments to determine material compatibility and paint stripping efficiency. Tests included Flammability, Viscosity, Longevity, Corrosion, Paint Stripping Efficiency, and Hydrogen Embrittlement. The laboratory procedures for each test were modified to best represent the operating conditions at the OO-ALC landing gear paint stripping operation. The corrosion and paint stripping efficiency tests were completed twice as part of the longevity test; once with new solution as received from the vender (denoted as "NS") and once with solution that was contaminated for 90 days with a 30% paint loading (denoted as "LS"). The purpose of conducting the Longevity test was to determine if the paint strippers lost their effectiveness within a 90-day period and to ensure that the material compatibility properties did not change with time. Table 1 summarizes the "Pass/Fail" results.

Table 1: "Pass/Fail" Laboratory Testing Summary Results

	Flammability	Viscosity	Corrosion		Paint Stripping Efficiency		Hydrogen Embrittlement	Overall "Pass / Fail"
			"NS"	"LS"	"NS"	"LS"		
Ecolink SAFE-STRIP	F	P	P	P	P	P	P	F
ALKOSURF 718	F	P	P	P	F	F	P	F
Gage Stingray™ 554	P	F	F	F	P	F	P	F
THERMACLEAN® 095-0048	P	P	P	P	F	F	P	F
Savogran S.I. No. 3	F	P	P	P	F	F	P	F
Savogran S.I. No. 8	F	P	F	P	F	F	P	F
Brulin Safety Strip 1000	P	P	F	F	F	F	P	F
Brulin Safety Strip HT	P	P	P	F	F	F	P	F
Calgon SPS-540T	P	P	F	F	F	F	P	F
Calgon SPS-570-81	P	P	F	F	F	F	P	F
CEE BEE A-235 (Control)	P	P	P	P	P	P	P	P

Based on the acceptance criteria developed at the start of this project, none of the 10 alternatives paint strippers tested successfully passed all of the criteria.

Out of the ten alternative paint strippers tested, one product, Ecolink SAFE-STRIP successfully met all of the criteria except one; the Flammability Test. Ecolink SAFE-STRIP failed one out of four of the flammability test trials by burning for one second longer than the acceptance criteria. Upon review of the preliminary test results it was concluded that Ecolink SAFE-STRIP should be further evaluated for implementation with the understanding that a process safety hazard may exist.

Step 5 - Compare the Best Alternative to the Current Process: Environmental Impact and Cost Benefit Analysis

The next step was to develop a direct comparison between the best alternative from Step 4 (assuming it passed all minimum laboratory testing requirements) and the current process. The direct comparison includes qualitative data from the laboratory testing to estimate waste generation rates and process characteristics of the alternative. In general, direct comparison includes all detail available and relevant to the actual process. Good starting points are: material safety data sheets, and the primary and secondary process boundaries identified in Step 1. A direct comparison of all environmental impacts helps ensure that the environmental problems are being reduced or eliminated, as opposed to simply being shifted to a different media (air, water, land).

A cost benefit analysis is a proven tool for evaluating the feasibility of implementing any type of material or process change. At a minimum, a cost benefit analysis identifies the estimated capital cost, the change in annual operating cost, the annual savings or loss, and the payback period. A combination of the capital cost and the payback period are generally used as the financial indicators to approve or disapprove a proposed alternative.

An abbreviated summary of the direct comparison of the phenolic methylene chloride stripper (CEE BEE A-235) and the top alternative selected for OO-ALC (Ecolink SAFE-STRIP) are presented in Table 2.

Table 2: Summary of Material Substitution Impacts on OO-ALC's Landing Gear Paint Stripping Operation

Driver	CEE BEE A-235 (Current Process)	Ecolink SAFE-STRIP (Direct Material Substitution Only)	Net Effect
HAP	86,724 lbs.	0 lbs.	100% Reduction
VOC	0 lbs.	79,155 lbs.	100% Increase
EPCRA §313	122,400 lbs.	661,123 lbs.	440% Increase
RCRA - Sludge	43,500 lbs.	707,465 lbs.	1,526% Increase
RCRA - PBM	350,000 lbs.	350,000 lbs.	No Effect
AFMC 24	121,176 lbs.	0 lbs.	100% Reduction
Capital Cost	NA	$507,026 + OSHA Upgrades	NA
Operating Cost	$875,182	$2,748,482	214% Increase
Annual Savings	NA	($1,873,007)	NA
Payback Period	NA	No Payback	NA

Replacing the entire 22,000 gallons of paint stripper every 90 days dominated as the main operating cost driver for the process. Assuming, the life-span of Ecolink SAFE-STRIP proved to be 180 days or 1 year the expected increase in annual operating costs decreases dramatically. Although the main goal of eliminating phenolic methylene chloride and corresponding hazardous air pollutant emissions from the process was accomplished, additional environmental impacts such as VOC emissions, TRI chemical releases, and increased hazardous waste generation were realized.

Step 6 - Identify Process Improvements

Performing a material substitution or process change may open new opportunities for process efficiency and pollution prevention that were not previously available. The addition of process improvements can often make an environmentally preferred alternative more financially attractive and environmentally better. One method of

identifying areas for improvement is to identify all of the areas having a "negative" effect on the operation from the direct comparison developed in Step 5.

At OO-ALC, process improvements were explored to offset the economic burden and reduce increased generation of VOC emissions, TRI chemical releases, and hazardous waste. Seven process improvements were identified; four of which had sufficient data to re-evaluate performing the material substitution. They are as follows:

- *In-Process Recycling - Vacuum Distillation* - In-process recycling of Ecolink SAFE-STRIP through vacuum distillation will eliminate the need to replace the solution, indefinitely, in turn reducing the volume of hazardous waste generated.
- *Reduce Liquid Surface to Air Ratio* - Reducing the evaporation rate will decrease the amount of paint stripper lost to direct emissions and decrease the demand for steam to heat the tanks. One method is to add hexagonal polypropylene floats (called Hexies) on the surface of the paint stripper. The vendor of Hexies states that field evaporation tests have demonstrated up to a 70% reduction in fluid loss from evaporation.
- *Implement a Closed Loop Rinse Cycle* - It is estimated that approximately 18,480 gallons of raw material would be lost to the rinse cycle per year; requiring an annual replacement value of $388,080. In addition, the loss of paint stripper is directly proportional to the amount of VOCs lost from the total process. It is estimated that 37.5 tons of VOCs will be transferred to the Industrial Wastewater Treatment Plant (IWTP) from the rinse cycle (equivalent to 97% of the total estimated VOC emissions from the paint stripping operation). A closed loop rinse cycle could eliminate a maximum of 97% of the total VOC emissions from the operation, as well as, reduce the amount of water used and the burden on the IWTP.
- *Implement a Sludge Management System* - A Sludge Management System would automatically remove the sludge from the tank bottoms on a daily basis and return the paint stripper back to the process tank. The remaining paint sludge would be dry (containing less than 1% paint stripper).

Step 7 - Evaluate Best Alternative with Potential Process Improvements

If sufficient data is available to estimate the impact of the process improvements on the overall process it is recommended to repeat the environmental and cost benefit analysis. Specifically in the case of material substitutions, additional process improvements that can be implemented simultaneously with the alternative can often improve the environmental and financial benefits to the point of changing a disapproval to an approved status.

The impact of implementing the process improvements identified in Step 6 with the substitution of Ecolink SAFE-STRIP for CEE BEE A-235 at OO-ALC resulted in an improved financial outlook (no payback period to an estimated 5.3 year payback period) and reduced environmental impacts from the total operation (99% in most areas of concern). Table 3 summarizes the material substitution impacts on OO-ALC's landing gear paint stripping operation with process improvements implemented.

Table 3: Summary of Material Substitution Impacts on OO-ALC's Landing Gear Paint Stripping Operation with Process Improvements

Driver	CEE BEE A-235 (Current Process)	Ecolink SAFE-STRIP (Direct Material Substitution Only)	Ecolink SAFE-STRIP with Process Improvements	Net Effect with Process Improvements
HAP	86,724 lbs.	0 lbs.	0 lbs.	100% Reduction
VOC	0 lbs.	79,155 lbs.	1,258 lbs.	100% Increase
EPCRA §313	122,400 lbs.	661,123 lbs.	1,222 lbs.	99% Reduction
RCRA – Sludge	43,500 lbs.	707,465 lbs.	8,969 lbs.	79% Reduction
RCRA – PBM	350,000 lbs.	350,000 lbs.	350,000 lbs.	No Effect
AFMC 24	121,176 lbs.	0 lbs.	0 lbs.	100% Reduction
Capital Cost	NA	$507,026 + OSHA Upgrades	$672,506 + OSHA Upgrades	NA
Operating Cost	$875,182	$2,748,482	$748,354	14% Reduction
Annual Savings	NA	($1,873,007)	$126,828	NA
Payback Period	NA	No Payback	5.3 years Excluding OSHA Upgrades	NA

Step 8 - Implement or Recommend Alternative Course of Action

The last step of the eight step identification and evaluation process was to review the benefits and limitations of the options presented and recommend a course of action to either implement the alternative or to investigate new methods to reduce the environmental health and safety impacts associated with the operation.

Based upon the findings of the OO-ALC landing gear paint stripping project the next steps are two-fold; a short-term and long-term. The short-term objective is to further evaluate Ecolink SAFE-STRIP on a 500-gallon scale up basis and to evaluate identified process improvements and required process changes. Fine tuning the process design for implementing Ecolink SAFE-STRIP will ensure a short-term solution for eliminating hazardous air pollutants, methylene chloride, from the operation in the event that the Aerospace NESHAP revisions are promulgated in the next several years. Following the results of scale-up testing the implementation of Ecolink SAFE-STRIP may prove to be more economically viable, therefore, warranting implementation.

The long-term objective is to develop a paint stripper that will both meet or exceed OO-ALC's performance requirements and be cost effective to implement and operate. To meet the long-term objective the following options are available:

A) conduct basic research to develop an environmentally friendly paint stripper that meets OO-ALC's performance requirements and is cost effective;

B) repeat the approach of evaluating commercial-off-the-shelf solutions can be on a 5 year basis to resample the market for new environmentally friendly paint strippers;

C) develop improved corrosion barriers to eliminate the need to paint landing gear components, therefore, phasing out the need for a landing gear paint stripping operation; and/or

D) develop improved non-destructive inspection technology to eliminate the need to remove the paint from the landing gear components for the sole purpose of performing non-destructive inspection.

SUMMARY

A successful short term solution was identified through AFRL's efforts to meet Ogden ALC's goal of replacing methylene chloride as a chemical paint stripper in the landing gear overhaul facility.

As in any case when making a material substitution there are trade-offs. This is very true in the case of chemical paint strippers. While phenolic methylene chloride is a known carcinogen, hazardous air pollutant, and identified as one of the Environmental Protection Agency's top 17 (EPA-17 Chemicals) chemicals for elimination; it strips paint fast, lasts for several years without having to be replaced, and only costs about $10 a gallon.

On the other hand, new environmentally friendly chemical paint strippers do not contain known carcinogens, hazardous air pollutants, or EPA-17 targeted chemicals. The drawback is that they tend to remove paint at slower rates, have shorter life-spans, and cost between $15 - $35 per gallon or higher depending on the formulation. In addition, environmentally friendly chemical paint strippers are largely comprised of volatile organic compounds (VOCs) that have a higher rate of evaporation the traditional phenolic methylene chloride blends.

Based on AFRL's findings a viable solution to OO-ALC landing gear paint stripping operation was successfully identified. With the use of process modifications, secondary in-process recycling equipment and sludge management technologies, alternative environmentally friendly chemical paint stripper are clearly the better environmental choice. In addition, applying total cost accounting to the landing gear paint stripping operations economic evaluation would further increase the projects financial feasibility through the reduction in recurring environmental costs.

Session XXVI
P² In Mission Readiness

Session Chairpersons:

Ms. Geri Hart, OC-ALC/EMV
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REMOVAL OF EMULSIFIED OIL AND AFFF USING AIR-SPARGED HYDROCYCLONE TECHNOLOGY

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ABSTRACT:

A range of Air Force (AF) activities generate wastewater containing suspended solids, oily substances, emulsion stabilizing agents, and aqueous, film-forming foam (AFFF) liquids. In a 1995 Small Business Innovative Research (SBIR) solicitation, the US Air Force was searching for a cost-effective method to handle this problem. This solicitation addressed two issues: (1) removal of emulsified oil, fuel, and grease from aircraft wash rack wastewater containing detergents and (2) removal of AFFF from firefighting wastewater.

A cooperative effort between AFRL/MLQ and Advanced Processing Technologies, Inc. (APT) has led to the development of Air-Sparged Hydrocyclone (ASH) technology. An ASH reactor can provide efficient removal of any hydrophobic particle in an aqueous waste stream. This includes emulsified petroleum, oil, and lubricant (POL) products. AFFF is removed via adsorption to hydrophobic particles. This technology can provide 80-100% removal of these contaminants from vehicle maintenance, vehicle wash rack, aircraft wash rack, jet engine test cell, and firefighting training pit waste streams.

The continuing SBIR Phase II work emphasizes on-site, pilot-scale tests with a trailer-mounted, mobile ASH unit modified from lessons learned during Phase I testing. The system has toured five different Air Force bases (AFB) and demonstrated its capability with various wastewater streams. The results of the demonstrations have confirmed that ASH technology is capable of effectively removing oil and grease, oily solids, and AFFF from these streams at low cost. Emulsified O&G and AFFF wastewaters can be treated for approximately $0.40-1.10 per 1,000 gallons. The contracted effort will be completed by 1 Aug 98. Installations of ASH units are being

planned for 325 CES/CEV and AFRL/MLQC, Tyndall AFB, Fla. and 17 CES/CEV, Goodfellow AFB, Texas.

INTRODUCTION:

A range of AF activities generate wastewater containing suspended solids, POL products, emulsion stabilizing agents, and AFFF liquids. These contaminants may pose a nuisance to federal or civilian industrial wastewater treatment plant (IWTP) operations or actually force the effluent stream to be out of compliance with local discharge limits. These concerns have been identified as Environment, Safety, and Occupational Health (ESOH) Needs #912, "New Treatment Technologies for Removing Low-Level Emulsified Oils in Contaminated Wastewater from Point and Non-Point Sources (High Priority)," #1414, "Pollution Controls for Aircraft Wash Racks (High Priority)," and #1609, "Methods to Mitigate Problems Associated with the Release of AFFF From the Flooding of Hangars as a Fire Suppressant (Low Priority)."[1] More information on these needs and the entire ESOH needs process can be found at the USAF Human Systems Center Environmental Planning Directorate's (HSC/XRE) Environment, Safety, and Occupational Health Technical Planning Integrated Product Team (ESOH TPIPT) website.

Conventional wastewater pre-treatment processes are either ineffective or too costly to treat emulsified oils caused by the use of soaps and detergents and AFFF releases. Gravity oil/water (O/W) separators are not able to separate the chemically stabilized o/w emulsions that exit from aircraft and vehicle wash racks. Separators incorporating coalescing media provide only a marginal improvement in separation efficiency.[2] Other pre-treatment unit operations such as thermal treatment, chemical demulsification, depth filtration, and combinations thereof, are capital intensive and usually have high operation and maintenance costs. Wastewaters containing AFFF need pre-treatment before being released to federally or privately owned treatment works (FOTW, POTW) due to its persistent foaming and high biochemical oxygen demand (BOD). Biological degradation may be economically successful if containment facilities and aeration equipment are available; otherwise, large capital expenditures are necessary. Also, long residence time, sludge removal, and intermittent flow may be barriers to an effective biodegradation process.

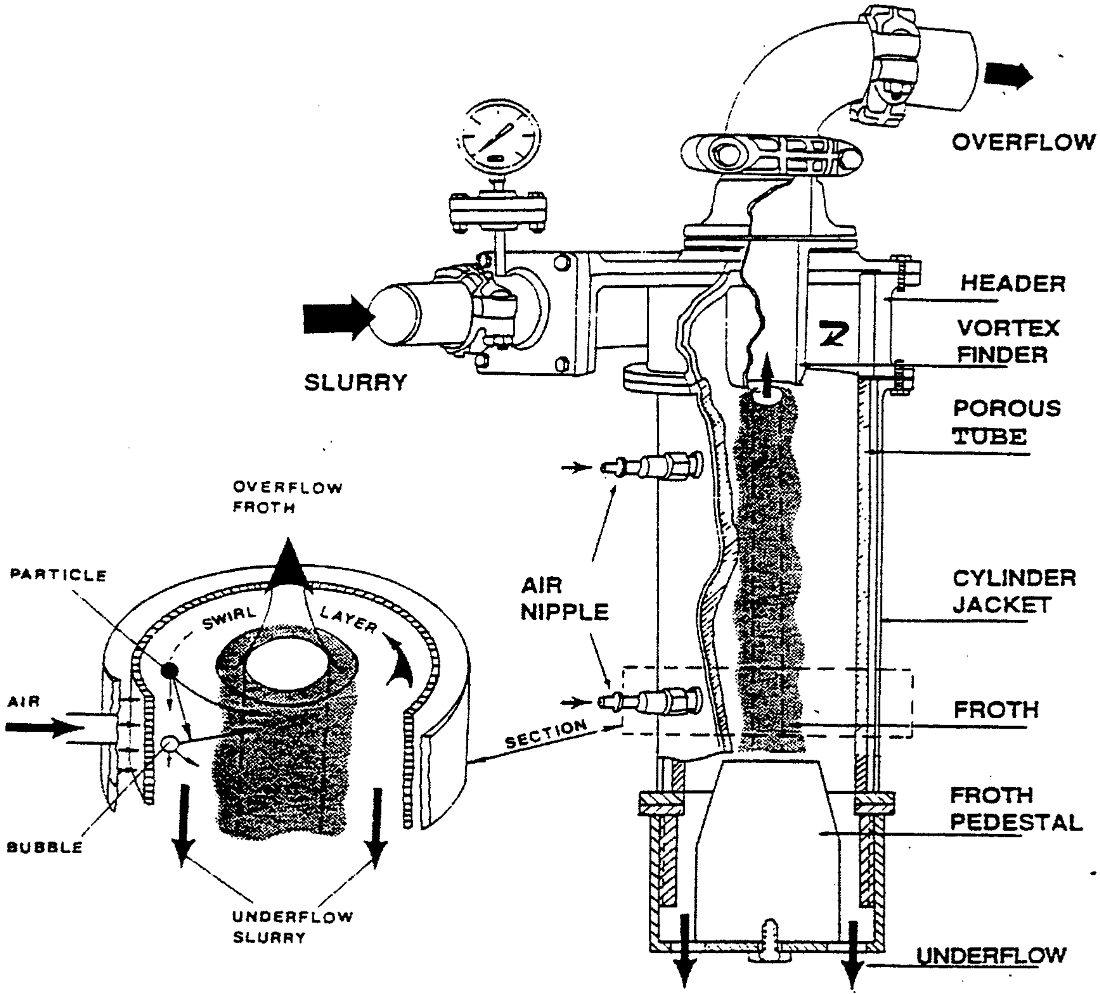
DISCUSSION:

AIR-SPARGED HYDROCYCLONE OPERATION

The air-sparged hydrocyclone unit removes hydrophobic solid particles or liquid droplets, including chemically emulsified oils, from wastewater. It consists of a jacketed, right-vertical, porous tube, a conventional cyclone header with a mounted vortex finder, and a froth pedestal/underflow structure that is centered on the cyclone axis at the bottom of the porous tube. See Figure 1. Wastewater is fed tangentially through the cyclone header to develop a swirl flow inside the porous tube. Pressurized air passes through the jacketed porous tube wall and is sheared into numerous fine bubbles by the high-velocity swirl flow of the suspension. Hydrophobic particles/oil droplets (or particles rendered hydrophobic by a chemical reagent) in the suspension collide with these bubbles, and, after bubble/particle attachment, are significantly reduced in their tangential velocity and transported radially into a froth phase which forms on the cylindrical axis. The froth phase is supported and constrained by the froth pedestal and thus moves towards the vortex finder of the cyclone header, being discharged as an overflow product. Cleaned water remains in swirl motion and is discharged as an underflow product through the annulus between the porous tube wall and the froth pedestal.

The design features of the ASH system improve the removal of fine particles in three ways. Firstly, a strong centrifugal force field is developed; the magnitude of the field is determined and controlled by the tangential velocity of the suspension and the cyclone diameter. This centrifugal force field results in increased inertia of fine particles and hence facilitates their collision and attachment to air bubbles. Secondly, the high-speed swirl flow exerts a considerable shear force at the porous tube inner surface wall. This, coupled with the fact that the air phase is introduced through extremely fine pores (35 - 140 microns), results in the generation of numerous fine air bubbles with average bubble diameter at about 100 microns. These small air bubbles are directed in the radial direction, orthogonal to the motion of particles contained in the swirl flowing water. As a result, the probability of collision of air bubbles with particles is significantly increased so that the collision event is no longer a rate determining process. Finally, the wastewater inside the ASH has two basic motions. One is the swirl motion along the circular inner surface of the porous tube, and another is an axial downward motion toward the bottom of the ASH. For a 2-inch inner diameter ASH 20 inches in length, any particular reference point in the influent wastewater may have approximately 9570 chances to collide with a freshly generated air bubble before it is discharged from the unit. It is these features that enable the ASH system to have a specific processing capacity (gallons processed per unit volume of the equipment) 100 - 500 times of any other conventional equipment. The ASH test unit used in all testing processed 20 gallons per minute (gpm). At that rate, each liter of wastewater resides in the ASH reactor (2.0-in. inside diameter, 24-in. long) for less than 0.25 seconds.

Figure 1. Schematic of the air-sparged hydrocyclone[3].



Designed And Manufactured By Advanced Processing Technologies, Inc.
Under Its Patent And Licenses From The University of Utah
US Patent 4,279,743 4,397,741 4,399,027 4,744,890 4,838,434 4,997,549 & Pending Applications

USAF SBIR PHASE II TEST RESULTS

At each test location, the wastewater for each test run was usually pulled from the o/w separator, floor sump, or containment structure that serviced the facility. Effluent characterization was determined from a one-liter grab sample collected adjacent to where the ASH feed pump was placed. The quality of the treated water was determined from a one-liter sample collected from the ASH discharge line after approximately ten minutes of operation. Independent laboratories conducted all chemical analyses, except AFFF concentrations, which were determined by APT. Quantitative values for total suspended solids (TSS), oil and grease (O&G), and total petroleum hydrocarbon (TPH) were obtained by EPA 160.2, EPA 413.1 or SM18 5520-B, and SW846 8015-M methodologies, respectively. Presently, there is no standard method to determine AFFF concentration in

solution. APT developed two semi-quantitative methods to determine AFFF removal from firefighting training pit effluents: foam height (FH) and surface tension (ST) measurements. In the first method, air is passed through a specific volume of AFFF solution until the produced foam layer breaks and rises no higher. Surface tension measurements were made with a Kruss K10T Digital Ring Tensionometer. Calibration curves were produced for each method as a function of AFFF concentration. Measurements of the untreated and ASH treated solutions were plotted on the respective calibration curves to determine AFFF concentrations. The FH and ST calibration curves will not return an absolute AFFF concentration for a specific sample; however, they clearly bracket an estimation of AFFF removal

Tests were conducted at Tinker AFB, OK (24-25 Mar 97), Tyndall AFB, FL (3 Apr 97), Eglin AFB, FL (5 Apr 97), and Goodfellow AFB, TX (19-22 Nov 97). The results of these tests are in Table 4[6]. Aircraft wash rack effluents (ACWR) tested at Tyndall AFB were obtained from the primary chamber of the servicing O/W separator. The AFFF contaminated effluents from firefighting training exercises at Tyndall AFB are collected in a lined lagoon after passing through an O/W separator used to reclaim free phase fuel. The fire training pit (FTP) lagoon water, which is presently being treated by an aerobic biological process to reduce TPH and BOD, is used as make-up water for the fire pits or metered into the sanitary sewer. This lagoon water was used in the ASH test. At Goodfellow AFB, FTP effluents are gravity fed to a lift station where they are pumped to a 500,000-gallon holding tank without any treatment. Water from the bottom of the tank is metered to the sanitary sewer, used for fire pit make-up water, or reutilized in the firefighting pump trucks. Water for the Goodfellow test was taken from the lift station. The cost to treat Goodfellow AFB FTP wastewater was estimated to be $0.34-$0.44/1000 gal.

Table 1 ASH Treatment of Various AFB Waste Streams.

Stream	Test / Sample	Influent (ppm)	Effluent (ppm)	% Removal
Tyndall-FTP	TSS-1	53	4	93
	O&G-1	94	6	94
	AFFF(FH)-1	800	100	94
	AFFF(ST)-1	100	12	88
Eglin-VMF	O&G-1	5250	31	99
Goodfellow-FTP	TSS-1	390	3	99
	O&G-1	1850	6	99
	TPH-1	1120	ND	100
	AFFF-1			80-90

* ND – Non Detect

SUMMARY/CONCLUSIONS:

Through extensive testing on AF waste streams containing suspended solids, emulsified fuels and oils, metals, and AFFF liquids, air-sparged hydrocyclone technology has provided a high level of contaminant removal at very low cost. With the construction flexibility of fixed or mobile configurations, ASH technology could be utilized in a wide

variety of AF applications. System attributes such as low capital cost, operation and maintenance expenses of only \$0.40-\$1.10/1000 gal, high throughput, process flexibility, and high contaminant removal rates, make the ASH an unbeatable value when designing wastewater treatment processes for AF waste streams. At the present time, a mobile ASH treatment system is being constructed for the 325 CES Environmental Flight, Tyndall AFB, Florida. In addition, a fixed ASH system is being constructed for AFRL/MLQC (Airbase Technology Development Branch) for installation at the 823 Civil Engineering Red Horse – Detachment 1, Silver Flag Fire Training Facility, Tyndall AFB, Florida. Also, a large, fixed ASH system is being considered for installation at the DoD Firefighting Training School, Goodfellow AFB, Texas.

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CLEAN AIR ACT COMPLIANCE THROUGH POLLUTION PREVENTION IN AIR COMBAT COMMAND

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ABSTRACT
In the next ten years, ACC will face compliance challenges with approximately 200 new National Emission Standards for Hazardous Air Pollutants (NESHAPs) to be promulgated and increasingly tighter National Ambient Air Quality Standards expected, to say nothing of the possible changes to the major source categories for criteria pollutants and Hazardous Air Pollutants (HAPs). For ACC, in the current arena of limited resources, continued process specific pollution prevention is the only viable means to compliance under the Clean Air Act (CAA). This paper discusses Air Combat Command's (ACC's) pollution prevention approach to compliance with the CAA.

The Aerospace NESHAP, in combination with Title V operating permits, is the first wave of CAA requirements to influence ACC's method for meeting it's primary mission, flying aircraft. Each process was evaluated to determine the greatest probability for emissions reductions; all large sources of air pollution on base, for example aircraft corrosion control, were identified with an increased focus on pollution prevention opportunities. By implementing the results of this analysis, supplemented by revision of air emissions inventories to incorporate more recent guidance and remove inaccuracies as well as modification

of permits and permit applications to include limits, ACC is avoiding the onerous requirements of Aerospace NESHAP by maintaining low levels of HAP emissions. ACC will now address reduction of emissions to below the Title V permit limits. ACC continually utilizes pollution prevention to reduce the regulatory requirements and liability for enforcement under the CAA.

INTRODUCTION

The increasing number of regulations promulgated as a result of the Clean Air Act Amendments and the rising cost of environmental compliance options results in the search for alternatives to traditional compliance avenues. ENVVEST, a program initiated by President Clinton, even allows regulatory relief for temporary non-compliance when the end result is compliance and substantially reduced air pollution. In Air Combat Command (ACC) we initiated pollution prevention initiatives to reduce the initial price and the overall cost of air quality compliance as well as decrease the regulatory burden. Our first initiative focused on the reduction of hazardous air pollutant (HAP) emissions to below National Emission Standards for Hazardous Air Pollutants (NESHAP) trigger limits, and we are currently involved in the reduction of criteria pollutants below Title V trigger limits.

ACC EMISSION REDUCTION INITIATIVES

The first focused initiative at ACC bases was to reduce the potential emissions from Hazardous Air Pollutants (HAPs) to below 10 tons per year for any single HAP and below 25 tons per year for total HAPs. This involved a combination of pollution prevention, correction and revision of our emissions data, incorporation of new policies, installation of control equipment and accepting federally enforceable limits. ACC defines pollution prevention as a change to the process resulting in reduced emissions or less hazardous emissions. This is often substitution of a paint or coating for one that emits reduced hazardous air pollutants, but still emits volatile organic compounds. Another example of pollution prevention is the exchange of a solvent washer for an aqueous parts washer; the exchange of a solvent, often a halogenated solvent, with a solution of detergent and water, much like a home dishwasher. This definition does not include control technology to reduce released emissions, or "end of pipe" fixes, but we include some of those here because none we used are required at ACC bases due to regulatory requirement

This initiative also included a complete review of all emissions data for each base, assessing accuracy of input data, calculations, and realignment with current Environmental Protection Agency (EPA), Air Force and ACC policies. We found adjustments to be made in all categories, resulting in greatly reduced emissions overall. Inaccuracies included misplaced decimal points in input data and overly conservative assumptions for emissions calculations. Realigning base data with new policies allowed us to use 500 operating hours for potential emissions for emergency generators, rather than 8760 operating hours. We subtracted known waste amounts from emission streams to more accurately reflect the process emissions. We also incorporated process limits for operations such as surface coating aircraft and vehicles[1], and used overall limits on gasoline and jet fuel to become minor sources for HAPs. Thus far, bases are taking limits that are still 3 to 5 times more than the base is expected to require, even in a mobility situation. The initial and current potential emissions for the ACC bases are provided in Exhibits 1 and 2.

After addressing the overall base compliance strategies, we then concentrated on the areas for greatest improvement, surface coating and fuels.

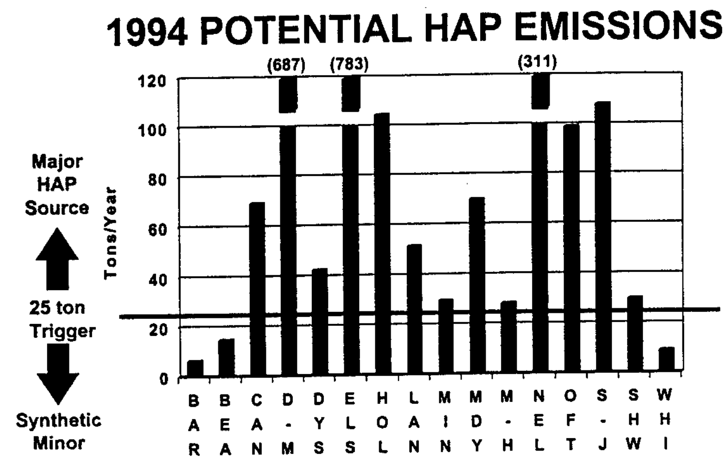

Exhibit 1: Potential Hazardous Air Pollutant Emissions for Air Combat Command Bases

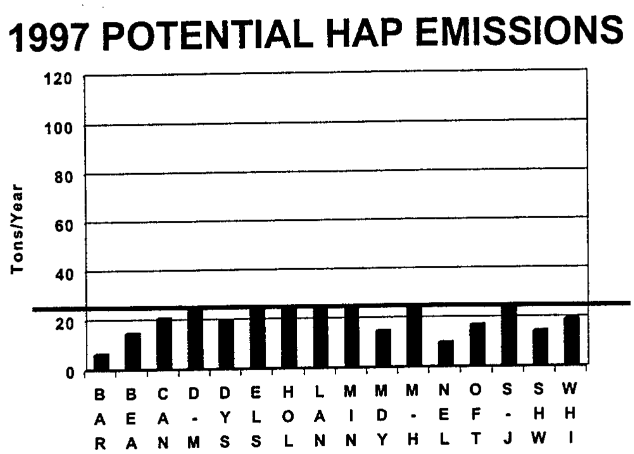

Exhibit 2: Revised Potential Hazardous Air Pollutant Emissions for Air Combat Command Bases

Surface Coating

Surface coating operations are the single largest source of pollutants, both HAPs and criteria pollutants, at a base. For reductions in this critical area, we focused on equipment and process improvements. We replaced the standard spray paint guns with High Volume Low Pressure (HVLP) spray guns to take advantage of the 90 percent transfer ratio. Some bases even installed electrostatic deposition guns for an even higher transfer ratio. Computerize paint measuring and mixing systems and automatic paint gun washers using low volatile organic compound (VOC)/low HAP solutions further allow emissions reductions through technology.

The first focus of our efforts to reduce emissions, both actual and potential, through process changes, was the documentation of our surface coating processes. Since ACC surface coating processes are batch processes, not continuous processes, 8760 operating hours for spray guns is not a realistic assumption. Our process limits require preparation of the aircraft or vehicle for painting (move it into the paint bay, tape off windows, etc.), painting of the aircraft or vehicle, then drying time (or cure time), and moving the aircraft or vehicle out of the paint bay before another one is moved in. We also found that our painters required training and a paradigm shift to realize material and emission reduction with the new spray guns. Our intensive 3 day training program for the painters resulted in increased transfer efficiency, reduced paint usage per paint job, reduced defects and repaints and a greater understanding of the recordkeeping requirements and importance of minimizing emissions. For individual training sessions, paint usage reductions of 30 - 50 percent are

common. Further process changes include more efficient loading of the automatic gun washers and utilization of extra nozzels to facilitate once per day wash cycles.

ACC is continuing the pollution prevention efforts for surface coating by developing specific application methods for each individual type of aircraft and each specific surface coating facility. We expect this ongoing effort to yield further benefits with reduced paint use per aircraft, improved quality of surface, reduced repaints due to inadequate surface quality, and increased life of surface coating as a result of greater consistency of coating thickness.

Fuels

Some ACC bases are installing control equipment to reduce emissions and ease record keeping. The best example is the installation of a vapor recovery system on a gas station. The gas station was designed to accept a vapor recovery system, yet the system is not required in the area. However, installation of the vapor recover system was relatively inexpensive and reduced potential and actual emissions by approximately 10 tons per year; a minimum of 88 percent reduction in VOCs, 49 percent of which are HAPs.

ACC saved many tons of emissions, VOCs and HAPs, by changing fuels from JP-4 to the less volatile JP-8. The emission factor for JP-8 is 0.1, compared with 2.69 for JP-4.

REDUCING REGULATORY OVERSIGHT

This leads to another benefit of pollution prevention, or emission reduction; reducing environmental liability and reducing regulatory oversight. ACC is accomplishing this by reducing the number of air sources that must comply with standards, reducing the number of standards that must be complied with and minimizing overall air emissions. The first initiative discussed above, reduction of HAPs, enabled ACC bases to avoid requirements of the Aerospace NESHAP. The reduction of criteria pollutants will enable bases to avoid the requirements of Title V permits, particularly severe due to the self-reporting and self-monitoring requirements. These two major efforts allowed bases to decrease the number of rules sources are subject to, and the number of sources subject to any rule. This reduces the number of chances for a notice of violation. We also believe these reductions lessen the chances of regulatory inspection.

ACC bases are also working to segment the Title V permit into a source consisting of the major source itself, but omitting many small, otherwise incidental, co-located sources. This can greatly reduce the liability and regulatory oversight expected from such a permit due to the alleviation of the self-monitoring and self-reporting requirements for the small sources. While this seems to allow for greater pollution, in these times of severely limited resources, it allows us to concentrate our resources on the major source to truly reduce emissions overall and better manage the emissions from the large source. The best example is the large corrosion control facility for aircraft where we install an efficient filtration system for VOC as well as HAP particulate and custom mixing equipment that allows us to reduce air emissions, paint usage and hazardous waste generation over the long run, rather than installing only VOC controls at the two other small corrosion control facilities for parts and occasional vehicle use in addition to the large facility. These changes, in combination with true elimination of sources no longer needed, allow ACC bases to reduce emissions and improve operational flexibility.

CONCLUSION

All requirements of the Clean Air Act encourage, if not require, emission reduction. By reducing emissions prior to the date required for compliance an installation can escape the more onerous requirements of the regulations and achieve the overall goal of reducing pollution and protecting the environment. The reduced regulatory impact also reduces the potential impact on mission from environmental concerns and reduces the cost of doing business from reduced permit fees, reduced permit maintenance and required controls. Therefore, pollution prevention, and emission reduction and control, for ACC is the key to mission flexibility.

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AIR FORCE BASE NAME ABBREVIATIONS

Abbreviation	Air Force Base Name
BAR	Barksdale
BEA	Beale
CAN	Cannon
D-M	Davis-Monthan
DYS	Dyess
ELS	Ellsworth
HOL	Holloman
LAN	Langley
MIN	Minot
MDY	Moody
M-H	Mountain Home
NEL	Nellis
OFT	Offutt
S-J	Seymour Johnson
SHW	Shaw
WHI	Whiteman

SESSION XXVII
P² PLANNING/P² INFORMATION SOURCES

SESSION CHAIRPERSONS:

Lt Colonel E. G. Willard, USAF, HQ AFCEE/JA
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MAKING THE DECISION: POLLUTION PREVENTION (P2) EQUIPMENT EVALUATION, PROCUREMENT, IMPLEMENTATION AND MONITORING

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INTRODUCTION

You have developed your P2 Plan, and it looks great! You have placed it neatly on the shelf, ready to be shown to whoever might ask if you have one. So, now what? Well, it probably makes a dandy reference of information and ideas, but how do you go about implementing the recommendations in the Plan? Simply put, what does it take to put your P2 Plan into action? We will take a look at some of the decision making and lessons learned at NAS Patuxent River.

How do you decide which P2 option is best for your needs? Some fundamental questions should first be answered. What is your primary objective? Is it waste reduction or saving money? Are you planning to select the best P2 options for achieving your waste reduction goals, or are you limited to selecting those options that show significant cost savings? Once you have made those decisions, there are several questions to consider to help you prioritize the options, put them into operation, and evaluate the results.

1) What processes contribute to your waste streams and which one should you tackle first?
2) What are your P2 options and how do you select the right ones?
3) How do you procure the selected P2 option, and what preparations should you make?
4) How do you know the P2 solution is doing the job and is a good value?

Note: The Flow chart in Figure 1 can help you with your P2 equipment implementation program.

CHECK OUT YOUR WASTE STREAMS AND PRIORITIZE YOUR WASTE REDUCTION EFFORT

What processes contribute to your waste streams, and which one should you tackle first? One of the first steps in developing a successful P2 Program is to identify the types and amounts of each waste stream. Then determine the processes and activities that generate those wastes. We considered three major categories of waste: hazardous waste, non-hazardous waste, and municipal solid waste (MSW).

The hazardous waste category may be your first priority for waste stream reduction due to safety, health, environmental and disposal cost considerations. Although a material may not be a hazardous waste as it enters a process, exposure to other materials during the process may render it hazardous. Consider starting with a less hazardous material (e.g., using solvents with a high flash point) to reduce the likelihood that you will have to dispose of a hazardous waste at the end of the process. Find out which processes contribute the most to your waste stream and see which activities are the primary users of those processes. Try to tackle the largest waste stream first.

Your non-hazardous waste category, which could include oil, antifreeze and alkaline batteries, may rank second in priority to hazardous waste for waste stream reduction. However, there could be exceptions. Perhaps you have a non-hazardous waste that is on the Toxic Release Inventory (TRI) list. Reducing that chemical has suddenly moved higher on the priority list. The concerns are environmental considerations and cost associated with disposal. Methods to reduce this waste stream may include substitution, reuse, and recycling. Again, try to reduce the largest and most toxic waste stream first.

The third category for waste reduction will likely be your trash disposal. Methods to reduce this waste generally require recycling. Find out, through waste characterization, what is recyclable in your waste stream (e.g., cardboard, paper, plastics, metal and glass). Since organic waste is generally a large waste stream component, consider composting at your facility. Determine what your local recycling market can support, and arrange to divert your waste to that market.

After the waste streams and the corresponding activities that yield them have been identified, the P2 team must prioritize waste reduction efforts. That priority can be established by a number of factors. For example, the substance may be considered a particular health risk (TRI chemical); it may make up a large portion of the waste stream; it could be economically desirable; or it just may be a simple program to implement (e.g., properly segregating and labeling waste oil to allow recycling through a refinery). What is important at your base? At NAS Patuxent River, our first priority was to reduce hazardous waste and reduce TRI chemicals exceeding 10,000 lb per year. We considered ways to reduce all waste streams but emphasized the largest waste streams as most important to the success of the program.

Examples: Targeting Waste Streams

1. When Air Operations replaces the ethylene glycol (our No. 1 TRI chemical) contained in the arresting gear fluid storage tanks, the arresting gear is disconnected and the 300-gallon storage tank contents are emptied into six 55-gallon drums. The spent ethylene glycol is then disposed. The cost of this operation for all eight tanks was calculated to be $15,057. Is there a way to reduce this waste, and how cost effective is it?

2. Abrasive blasting for depainting is the largest recurring source of hazardous waste at Patuxent River Naval Air Station. The primary type of media used is a Plastic Media Bead (PMB) and it accounts for up to 40,000 pounds of waste per year. Can anything be done to eliminate or reduce this waste?

RESEARCH YOUR P2 EQUIPMENT OPTIONS & MAKE A DECISION

What are your P2 options, and how do you select the right ones? Now that you have figured out the processes and waste streams to target, it's time to check into potential waste reduction alternatives. Often more than one solution exists, and the relative merits of each should be considered. For instance, should used oil be transported to a refinery or can it be recycled on site and used as a diesel fuel additive? Your P2 team must research possible solutions and alternatives and use that information as the basis for a reasonable cost-benefit analysis. The research does not end here; new information can turn up to alter the course of a given procurement.

Example: Flexible Decision Making

After researching and analyzing the solvent recovery options, we decided to purchase a distillation unit to separate and recycle spent solvents on site. While the unit was in procurement, two issues came up and caused us to reconsider the decision. We could not be certain that recycled fluids would meet original performance specification, and we found out that a similar unit had exploded at another facility. We decided to cancel this order and shift to filtration devices for use on solvent parts washers and paint gun washers to extend fluid life.

It's a good idea to have a well-researched "wish list" of potential P2 options for purchase. If funding becomes available, particularly at the end of a fiscal year, your "shopping list" may give you the edge

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when competing for scarce funding resources.

Keep informed. New techniques are constantly being devised to reduce pollution. Keep abreast of the latest developments through the P2 Opportunity Handbooks, conferences, magazines, the Internet, vendor literature and the people in your shops.

After an idea has been researched and is found to be cost effective, how do you go about selecting the equipment? The team should first consult the *Tri Service P2 Opportunity Handbook* and the *Navy P2 Equipment Handbook.* Both are available via the Internet. These documents identify common waste streams and corresponding P2 process and equipment options to consider for implementation. Using established P2 options can speed your research, stimulate ideas, and may make the procurement process a little easier. Your P2 team can expand your research by consulting with existing users of the equipment, manufacturers, vendors, and trade publications for more up-to-date information on the latest practices and equipment. Discussing the new equipment with the planned users of the equipment can yield a wealth of insights and help gain acceptance of the planned changes. This extra effort should pay off in the long run by giving you a better product and a satisfied user.

Once you have decided on the type of P2 equipment to do the job, it's time to figure out which model to purchase. This may or may not be answered by the cost study performed in the research stage. The P2 team may have to prepare further cost-benefit analyses to determine the most economical model to purchase. Keep in mind that the most cost effective solution may not be the most environmentally desirable or have the biggest impact on waste stream reduction. Here is where your P2 team must decide what is more important.

Examples: Choosing The Best Buys

1. We wanted to recycle 8 tanks (about 2,400 gallons) of arresting gear fluid. We identified several manufacturers that sell antifreeze recyclers. One of the selected models could only process 3.2 gallons per hour and was deemed inadequate. The following table illustrates a cost comparison between the remaining prospective models. Having pre-determined the present cost of changing antifreeze, it can be seen that antifreeze recycling is cost effective and which unit is the best buy. At first glance you might choose option "A" for having the quickest initial cost recovery, but actually option "C" gives the best value for its largest recurring savings.

Table 1. Arresting Gear Fluid Recycling Equipment Comparison

Manufacturer	A	B	C
Type of Recycling	Upgrade Existing Equipment	Ion Exchange	Chemical Pretreatment and Filtration
Process Rate per Hour	55 gallons	100 gallons	100 gallons
Initial Procurement Cost	$162	$9,995	$2,500
Material Cost per Changeout	$5,840	$7,787	$1,237
Disposal Cost per Changeout	$209	$209	$84
Labor Cost per Changeout	$2,951	$374	$2,452
Total Cost per Changeout	$9,000	$8,370	$3,773
Current Changeout Costs (8 tanks)	$15,057	$15,057	$15,057
Savings per Changeout (8 tank)	**$6,057**	**$6,687**	**$11,284**
Savings per Changeout (1 tank)	**$757**	**$836**	**$1,411**
Initial Cost Recovery (# tanks)	**1st tank**	**12th tank**	**2nd tank**

2. A firm has developed a process whereby the plastic media bead (PMB) used in abrasive blasting is recycled into cultured marble products, such as sinks and countertops. The

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following table illustrates the cost comparison between the present disposal method and the proposed method.

Table 2. Projected Additional Cost if PMB Recycling Had Been Implemented

OPERATING YEAR	1994	1995	1996
CURRENT METHOD:			
PMB Disposal (lb.)	15,800	30,097	41,539
Media Purchase	$20,224	$30,699	$61,062
Media Disposal	$7,426	$14,146	$11,631
Steel Drum	$1,080	$2,040	$2,800
Delivery/Pickup	$451	$451	$451
Placarding	$24	$46	$63
TOTAL OPERATING COSTS	**$29,205**	**$47,382**	**$76,007**
PROPOSED METHOD:			
Media Lease	$33,180	$61,699	$85,155
Media Disposal	N/A	N/A	N/A
Steel Drum	N/A	N/A	N/A
Delivery/Pickup	N/A	N/A	N/A
Placarding	N/A	N/A	N/A
TOTAL OPERATING COSTS	**$33,180**	**$61,699**	**$85,155**
ADDITIONAL COSTS	**$3,975**	**$14,317**	**$9,148**

The economical choice would be to continue the current practice. However, our P2 Committee decided that the reduction in hazardous waste and the environmentally friendly method of recycling (plus the positive public recognition benefit) were worth spending the extra funds. Although not a P2 equipment option, this scenario shows an example of how it might make sense to select an option that may never pay for itself in dollars.

Buy Your P2 Equipment & Get Ready For Delivery

How do you procure your selected P2 option and what preparations should you make? Now that you have decided what to buy, how do you get it into the users' hands? Do you have funds available for the purchase or do you need to request funds from a higher authority? You may need to project a payback period to justify the purchase.

First check out the Navy P2 equipment procurement program. This is a program through which the Navy has already researched the P2 benefits of selected equipment and a base can take advantage of the volume discount, installation, training and logistics support. If you are procuring directly from the manufacturer, you may need to draft a contract, sole source justification, or list three competitive vendors.

Quite often your equipment purchase will require some sort of site preparation. This can range from simply having a place to store it (if the equipment is a portable device), to providing concrete slabs, shelter, electrical power, containment, or plumbing. In any event, this is an issue your P2 team should consider. You must see to it that the appropriate personnel (e.g., electricians, carpenters, plumbers) prepare the physical site. Make sure that you organize any necessary training before and after the equipment's arrival. Invariably there is accompanying paperwork that needs to be documented when the equipment arrives on site. You will need to keep track of the placement of each piece of equipment.

Keep Your P2 Equipment Operational & Track its Performance

How do you know the P2 equipment is doing the job and is a good value? Consider building a database to measure the performance of each piece of equipment. Once the equipment is in place, you need to monitor it to evaluate and maintain its effectiveness. Consistent monitoring can detect problems early

enough to avoid excessive down time and can provide data that can help you ascertain the cost effectiveness of the program. The monitoring program requires the P2 team to establish a rapport with the individuals who are responsible for operating and maintaining the equipment. They are an invaluable resource to consult when determining the equipment's capabilities. The comments and the data they provide are critical to quantifying and assessing the results of the P2 initiative. You can use this information to help you with future procurement decisions.

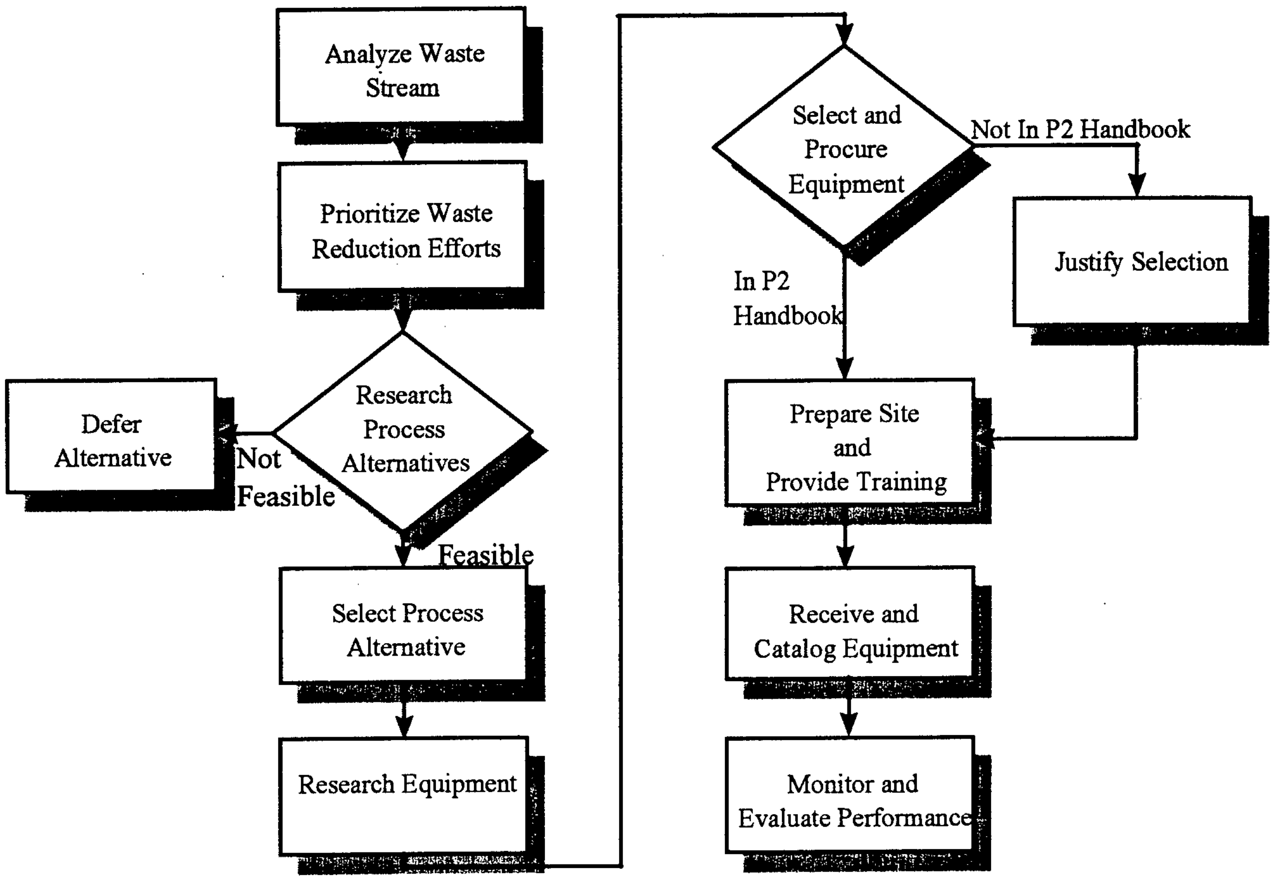

Figure 1. P2 Equipment Implementation Flowchart

ROADBLOCKS TO IMPLEMENTATION

Every new program meets with resistance of some sort, and pollution prevention is no exception. Human nature, being what it is, resists change. There undoubtedly will be individuals with an "If it isn't broken, don't fix it" attitude to overcome. It is part of the P2 team's job to persuade these individuals that there is a better way to complete their activities. Typically, there are other benefits besides pollution prevention (e.g., safer to use, time savings, cost savings) that can motivate these individuals to try a new approach and help it succeed.

Of course there is the ever present question of spending. It will be much easier to gain funding if your P2 team can propose a solution that is economically beneficial. However, not all pollution programs have a dollar benefit associated with them. Some programs need to be implemented because they are mandated, others because they reduce health risks, or simply because they are in the public's interest. In any event, it is the P2 team's responsibility to try to present the most cost effective "best value" solution.

CONCLUSION

Your P2 team will make your Pollution Prevention Program successful through a concerted effort to implement recommendations in your P2 Plan and evaluating the results. Your P2 team will carry out this responsibility by identifying the key wastes, developing a cost effective method to reduce them, initiating and implementing the solution, and monitoring and evaluating the program's performance. With a vision to keep your P2 Program on track, you will reach your P2 goal through persistence and a determination to make it work.

Fast, Cheap, and Easy Pollution Prevention Plans for Small Sites

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The Department of Defense (DoD) has numerous small sites with simple processes and few waste streams. Because these sites also tend to have minimal environmental resources, pollution prevention plans (which are not a regulatory requirement) have been postponed. The following paper provides a useful methodology for completing pollution prevention plans for groups of small sites as well as some specific recommendations that will improve the process.

CDM Federal Programs Corporation (CDM Federal) recently prepared pollution prevention plans for the Army=s 63rd Reserve Support Center (RSC). A plan was written for each of 12 small Army Reserve sites in California and Arizona. The sites had common processes, primarily related to vehicle maintenance. The work was accomplished efficiently and economically using a simple four-step procedure.

Initially, CDM Federal conducted a field survey of the sites to collect general site information and data on each process, including:

- Facility name
- Primary point of contact (POC) name and job title
- Secondary POC name and job title
- Phone number(s)

The multiple points of contact allowed for easy access when follow-up information was needed. Generally, the points of contact were the facility manager and the hazardous waste/ environmental coordinator. For each processes, the following data was collected:

- Process description
- Equipment type
- Equipment number
- Production unit
- Production rate (per year)
- Number of people using the process
- Labor hours
- Level of personal protective equipment required

- Permit information
- Materials used (including manufacturer, quantity, and shelf life)
- Wastes generated (including RCRA code, quantity, and disposal method)

A process diagram was sketched based on the operator=s description of the process. Also collected were any current pollution prevention measures and any known potential pollution prevention measures. This is important, because the operators and other shop personnel know the process best and so are more likely to know which changes will or will not work.

For the second step, CDM Federal researched potential measures to reduce pollution. Because pollution prevention guidance is based on process type or waste streams, these two pieces of information became the focus of the search. During the field survey, common processes across sites had been determined so they could be categorized. This simplified research. Even with limited background in pollution prevention, it is possible to produce recommended measures for most processes using the many resources available through DoD, local, state, and federal agencies. (A partial list of resources available to the public appears at the end of this paper.)

The third step was the development of a model pollution prevention plan. For this plan to be effective, CDM Federal identified one site that best represented all 12 facilities. The model site selected was one of the largest sites and had the most processes that were common to the whole group. Use of the model plan prevented duplication of effort in many areas such as cost analysis, process diagrams, and introductory/background text. The pollution prevention plan was written for the site based on Army guidance (Pollution Prevention Opportunity Assessment Protocol dated 15 October 1994).

Finally, pollution prevention plans were written for the additional sites based on the model plan. Because so many of the sites were similar, the process allowed for a quick production time for each of the additional sites. By assigning multiple personnel to the surveying and plan writing for the 11 additional sites, CDM Federal was able to compress the schedule even more. The initial combined survey and the model plan provided consistency for the project. To reduce costs and expand staff knowledge, a less experienced technical employee can be used to write the additional plans. By reading the worksheets and following the model, they can learn about pollution prevention while easily making the conversion to a new site. A more experienced worker can then add information needed for new processes.

In addition to the above methodology, some guidelines were used to create more useful documents for the Army. For example, it is important to customize recommendations to the type of work done and the organizational structure. Because these were small maintenance shops (as is the case with many military shops), CDM Federal recommended primarily administrative and low-cost technical pollution prevention measures. These included simple methods such as ordering in smaller quantities, centralizing hazardous material, and preventing spills. For most small maintenance shops, high-tech, expensive equipment and extensive tracking of materials and waste are not practical. The return on investment is too small for these types of projects. The Army Reserve is organized in such a way that one environmental support staff serves multiple sites. Certain measures take advantage of this organizational structure by using centralized programs. Examples include implementing a single training and awareness program and promoting the sharing of pollution prevention ideas among facilities. Each of these can be initiated and facilitated by the central office with a small amount of effort, but the can have large impacts on pollution prevention at many sites.

The final plans should be simple and straightforward, avoiding environmental jargon and lengthy explanations. On-site personnel should be able to read and use the plans without excessive assistance from environmental personnel. Large, detailed documents not only cost more, but also deter shop personnel from reading them. By engaging these workers, implementation of the recommended measures becomes much easier.

CDM Federal completed all 12 pollution prevention plans for the 63rd RSC in six months using only two employees and the customer was pleased with the results. By following these guidelines, other organizations can generate useful pollution prevention plans quickly, easily, and at a low cost for small sites.

# # #

Air Force CEE
Provides information on pollution prevention projects implemented by the Air Force
Web site: http://www.ascee.brooks.af.mil.pro-act

CalEPA ACCESS
Electronic bulletin board system which provides copies of full text or executive summaries of pollution prevention documents
Bulletin Board: (916) 322-5041

Center for Environmental Research Information
EPA organizations that provides technical documents at no charge
Phone: (513) 569-7562
Fax: (513) 569-7566

Coating Alternatives Guide (CAGE)
Electronic guide developed by Research Triangle Institute for identifying alternatives for metal parts coating based on process information
Phone: (919) 541-6916
E-mail: cagemaster@clean.rti.org
Web site: http://clean.rti.org/cage

DTSC Pollution Prevention and Technology Development
Department of DTSC delegated with responsibility to oversee pollution prevention issues; manages a technology clearinghouse which provides reports at no cost and videos for a fee
Phone: (916) 322-3670
Fax: (916) 327-4494

Enviroene
EPA=s electronic guide to pollution prevention, compliance, and enforcement
Web site: http://es.inel.gov

Joint Service Pollution Prevention Technical Library
A comprehensive resource for information on technologies and management practices to prevent pollution at military installations; contents of library: Joint Service Pollution Prevention Opportunity Handbook, Navy Pollution Prevention Equipment Book, DLA Environmental Products Catalog; web site allows user to read, search, print, or download information; ideas are submitted by fax or email
Fax: (808) 471-5704
E-mail: lhill@nfesc.navy.mil
Web site: (through NFESC=s home page)
http://enviro.nfesc.navy.mil/p2library
(through DENIX)
http://denix.cecer.army.mil/denix/public/library/library.html

National Center for Environmental Publications and Information
Provides pollution prevention documents at no charge
Phone: (800) 490-9198
Fax: (513) 489-8695

National Technical Information Service
Provides pollution prevention documents for a fee
Phone: (703) 487-4780 (to identify a title)

Pollution Prevention Information Clearinghouse

Distribution center for EPA documents and fact sheets dealing with source reduction and pollution prevention; also provides references and referrals for pollution prevention questions
Phone: (202) 260-1023
Fax: (202) 260-4659
Email: ppic@epamail.epa.gov
Web site: http://www.epa.gov/opptintr/p2home

RLIBY (Research Library)
Database of more than 12,000 pollution prevention articles, pamphlets and other documents maintained by Waste Reduction Resource Center; additional resources also available through the web listed below
Phone: (800) 476-8686
Web site: http://www.p2pays.org

Solvent Alternative Guide (SAGE)
Electronic guide developed by Research Triangle Institute for identifying the most suitable cleaning option based on process information
Phone: (919) 541-8031
E-mail: sagemaster@clean.rti.org
Web site: http://clean.rti.org

DENIX: The Tool Kit for Success and Partnering

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Under Contract to:
Defense Environmental Security Corporate Information Management Program Office

DENIX, the Defense Environmental Network and Information eXchange, is the World Wide Web standard system for all Department of Defense (DoD) Environmental Security Professionals. This system facilitates exchange of information and ideas between all DoD Environmental Security professionals world wide and promotes free exchange of information with people outside the Department, such as other Federal and State government organizations, Native Americans, International organizations and the public at large. The system has many capabilities that facilitate communication and conducting business operations as well as a great depth in current events, news and information.

DENIX serves as a centralized platform for the dissemination of policy and guidance, access to information sources and transmission of data up and down the command chain. DoD's environmental policy emanates from the Office of the Deputy Under Secretary of Defense for Environmental Security (DUSD(ES)). This office maintains a hands-on interest in the development of DENIX and other systems supporting environmental programs within DoD. DUSD(ES) serves as the primary functional proponent for DENIX, supplemented by tri-service representatives.

DENIX provides access to vast repositories of information. Annually, DENIX is utilized by more than 4,000 DoD personnel, who are involved with environmental programs from the installation level up to the policy-making level of the DUSD(ES) Office. These users login to the system for timely access to information on:

Air
Cleanup/Installation Restoration
Compliance
Conservation and Natural/Cultural Resources
Environmental Planning
Explosive Safety
Hazardous Substance Management
International Activities
ISO 14000
Land
Native American
Noise
Pest Management
Pollution Prevention
Safety/Occupational Health/Fire
Toxic Substances
Water

The depth and richness of the information in these topic areas makes DENIX an essential tool for the environmental professional at all levels. The following features provide DENIX users with a wide range of methods for accessing information:

The calendar of environmental events - A calendar which is can be interactively updated by the user community and can be used as a planning tool for scheduling meetings, conferences, workshops and training events.
Links to other environmental Web sites - Numerous federal, state, and public sites can be directly accessed through hypertext links.
Central subscriptions to environmental news, regulations, and technology - Updated proprietary subscriptions to journals such as the BNA's "Daily Environmental Report," the weekly "Inside EPA," and the "Defense Environmental Alert".
Online access to current federal and state regulations - Full text of state laws and regulations which are searchable by key words.
Enhanced search engine - The improved search engine on DENIX links to 34 carefully selected sites which keeps user queries focused within the applicable environmental domain.
Ongoing discussion forums - A special area posted throughout the life-cycle of a project or work group to aid in communications relating to the project.
Chat room - Real time discussions among environmental professionals.
Upload/download features - Many systems enable file downloads only. By providing two way capability, reporting is facilitated both up and down command channels.

There are four unique menu areas on DENIX: DoD, Public, State and International. Eligible DoD environmental professionals wishing to obtain a login to the restricted DENIX DoD area may do so online at: www.denix.osd.mil. DUSD(ES) strongly encourages members of the contracting community to access DENIX. There are some restrictions for contractor eligibility to access the DoD menu. The contractor must be currently supporting a DoD environmental contract, and contractors will be blocked from viewing the daily and weekly online environmental journal subscriptions. The State and International menu areas require registration. This form is also available at the URL shown above. There are no limitations to the Public menu of DENIX.

The system facilitates DoD outreach to other Federal, State and international organizations. For instance, a joint partnership between DoD and the Environmental Council of the States (ECOS) resulted in a new menu item dedicated to the special issues impacting the states. DENIX supported early NATO committee efforts to exchange information on environmental cooperative agreements among the NATO community. A new initiative provides a dedicated DENIX menu area for American Indians, Alaska Natives, and Native Hawaiians environmental programs

The DENIX International menu serves as a platform to facilitate work in various cooperative arrangements where DOD is working with other organizations or countries. For example, the US-Swedish Defense Environmental Cooperative Agreement between the Department of Defense of The United States of America and The Armed Forces of The Kingdom of Sweden for Cooperation on Environmental Protection in Defense Matters uses the DENIX

International menu. Other related initiatives which, like the US-Swedish initiative, use DENIX as a communications medium and feature special program related menu area items on the system:

US/Canada/Australia Trilateral Forum
Arctic Military Environmental Cooperative Agreement (AMEC)
Environmental Cooperation in the Baltic States
Department of State Environmental Hubs program.

DENIX is also used to provide users with information on the development and implementation of innovative environmental technologies. A page on Remedy Selection/Remediation Technology provides over twenty Application Analysis Reports on site specific case studies of cleanup technologies that have been implemented at DoD and Department of Energy installations. These case studies document site specific examples of the performance, cost, regulatory issues, and lessons learned in implementing an innovative technology. Links to other federal agencies and private sector Web sites are also available to exchange cost and performance data in this same format.

As DENIX continues to improve, it is experiencing a rapid growth rate. The ultimate goal of the cooperating organizations is to promote a scenario where DENIX becomes a knowledge station for all DoD environmental security professionals. With DENIX as the entry point they will be able to accomplish most of their research, reporting, and communications requirements from a single point of entry.

In summary, DENIX is a dynamic system. Its origins are in the tri-services bulletin board systems, its present is a compilation of environmental tools, information and data, and its future will be shaped by the needs of environmental professionals and evolving environmental requirements as set by policy and legislation.

Joint Service Pollution Prevention Technical Library

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At a time when Department of Defense (DoD) agencies are faced with increasingly scarce resources and must accomplish their missions despite reduced funding; partnership and information sharing among the joint services is vitally important. Recently, the Defense Logistic Agency (DLA) and Headquarters Marine Corps (HQMC) have joined with the Army Environmental Center (AEC), the Air Force Center for Environmental Excellence (AFCEE), and the Naval Facilities Engineering Service Center (NFESC) to coordinate a project of mutual interest -- the development of a comprehensive information resource of pollution prevention (P2) technologies used within the joint services and private industry. The services have joined efforts to produce a valuable P2 reference document that will benefit each of the services equally. The result of this partnering effort is the **Joint Service Pollution Prevention Technical Library**.

The Joint Service P2 Technical Library is a single comprehensive resource for information on equipment, technologies, and management practices which reduce or eliminate the generation, disposal, and release of pollutants at joint service installations. The P2 Technical Library is an excellent source of the lessons learned and success stories throughout the joint services, and is useful for researching pollution prevention opportunities during P2 plan development and other projects.

The Joint Service P2 Technical Library currently consists of the:

- **Joint Service P2 Opportunity Handbook**

The P2 Opportunity Handbook is a tool for sharing pollution prevention information throughout the joint services. The purpose is to inform each service about P2 efforts that are being investigated and adopted throughout the services and to minimize duplicated efforts by sharing their lessons learned. This resource identifies available "off-the-shelf " P2 technologies, management practices, and process changes that reduce or eliminate the amount of hazardous and solid waste being generated at joint service facilities. The management practices and technologies in the P2 Opportunity Handbook are divided into sections by subject area and are presented in the form of technical data sheets. Currently the P2 Opportunity Handbook subject areas include: Solvent Substitution; Ozone Depleting Substances; Electroplating and Bath-life Extension; Painting Processes; Paint Removal Technologies; Wastewater Management & Reuse; Stormwater Management; Petroleum, Oil, and Lubricants Recycling and Reuse; Hazardous Material & Hazardous Waste Management; Pre-Production Equipment; Solid Waste Management; and Air Pollution Issues.

♦ **Navy's P2 Equipment Book**

This is a valuable resource for identifying commercially available P2 technologies already being purchased and evaluated through the Navy's P2 Equipment Procurement Program. In it you will find equipment summaries containing detailed information on equipment characteristics, implementation requirements, benefits, associated costs, and points of contact for further assistance. The equipment is specified and procured under two complementary initiatives, the *Preproduction Initiative* (i.e. technology demonstration) and the *Competitive Procurement Initiative*. All of the equipment presented in the P2 Equipment Book has been procured and is being tested and used at Naval facilities. This resource is also available to, and in some cases is being used by the other services as well. The P2 Equipment Book provides information on more than 100 pieces of equipment.

♦ **DLA's Environmental Products Catalog**

DLA's Environmental Products Catalog, is maintained by the Defense Supply Center Richmond. This is a user-friendly publication which clearly suggests alternatives to previously used products or processes. These alternatives may be less toxic, non-ozone depleting, or promote recycling and waste minimization. The catalog has an extensive 'Points of Contact' section for customers requesting additional information. There is also an on-line catalog that provides a quick listing of available products and allows on-line orders to be placed.

♦ **Joint Group on Acquisition Pollution Prevention (JG-APP)**

JG-APP was established to overcome duplication of efforts in changing military specifications/standards, budget constraints for pollution prevention, and to establish common test protocol acceptance of alternatives. Their objectives are:

- Reduce or eliminate hazardous materials
- Foster joint services cooperation
- Provide single interface to weapon systems program managers
- Provide a bridge to the Sustainment Community

The P2 Technical Library has recently added a *Shop's Directory* that is an easy way to cross reference the information in the Library according to the different activities being done in the various shops throughout the joint service community. The Shop's Directory is broken down by:

- Service,
- Primary installations responsible for maintenance and repair for each service,
- Shops within each installation,
- and the activities being done within each Shop.

Once the user decides which shop they are interested in, they can click on the activity within that shop and get a list of the related data sheets and applicable equipment. Another recent addition is the *NSN Section*. This section was added to each applicable data sheet and lists the appropriate National Stock Numbers (NSNs) for the products and/or equipment mentioned in each data sheet. This section will also allow users to access the Material Safety Data Sheets (MSDSs) for each NSN (*this feature is only available for the P2 Opportunity Handbook*).

You can access the Joint Service P2 Technical Library via our homepage at **http://enviro.nfesc.navy.mil/p2library** or as software. The software, which is written in Adobe Acrobat®, is distributed on CD-ROM through our distribution list or at various P2 conferences, and can also be downloaded from our homepage. The software allows you to search, print, or read the information in the Library in its entirety. The software is updated annually as NFESC, AFCEE, AEC, HQMC, DLA, JG-APP and other technical agencies continue to investigate and develop new hazardous waste and solid waste management practices and technologies. For further information about the P2 Technical Library, or to be placed on the distribution list for future copies, please contact Mr. Larry Hill at lhill@nfesc.navy.mil.

SESSION **XXVIII**
ENVIRONMENTAL MANAGEMENT SYSTEMS/
P2 MANAGEMENT

SESSION CHAIRPERSONS:

Mr. Mark R. Gregory, Defense Enviro Security
Mr. Dan L. McNally, Dept of Sci and Tech,
Mr. Gerald B. Kos, Syrius Rsch Inc.

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Environmental Inventory Management (EIM)

What is EIM?

Environmental Inventory Management (EIM) is a suite of integrated environmental security management modules for use by personnel at DoD installations. EIM consists of seven modules defined by the following functional areas: Hazardous Substance Management, Air Quality Management, Water Quality Management, Tank Management, Toxic Management, Solid Waste Management and Pest Management. These modules will enable personnel to fulfill their day-to-day data requirements, support their corporate reporting needs (through Environmental Security Corporate Reporting Suite) as well as address certain Federal, State and local government reporting requirements.

EIM will interface with automated information systems (AIS) for such business areas as safety and occupational health, logistics, personnel management, and finance. Since the EIM suite of modules operates on an integrated database, values for data elements that are common to two or more modules need only be entered once, therefore reducing the workload and the chances for data entry error.

What are the ES management areas of EIM?

Hazardous Substance Management (HSM)

The Hazardous Substance Management (HSM) Module is designed to assist commanders and managers in: receiving, storing, distributing, and tracking hazardous materials; tracking and managing the emissions and wastes that are generated when hazardous materials are used; and keeping accurate records of all related processes. The HSM module will maintain an inventory of all hazardous chemicals contained in hazardous materials stored and used, in the emissions that are generated during use, and the wastes generated and containerized. It will produce the necessary federal, state, and local required environmental and management reports. This module is based on and supports the step-by-step ES management business practices of all of the Military Services and Defense Agencies. It fully supports DoD depot maintenance activities and the high volume use of hazardous materials found in those operations.

Water Quality Management (WQM)

The Water Quality Management (WQM) module consists of four sub modules that support Wastewater, Industrial Pretreatment, Stormwater and Potable operations. These sub modules compile and track compliance information in support of the Clean Water Act (CWA) and the Safe Drinking Water Act, including National Pollutant Discharge Elimination System (NPDES) permits. The primary purpose of WQM Module is to conduct day-to-day data collection for use in monitoring, evaluating, and adjusting throughput and parameters as required to ensure compliance with Federal, State, Local, and Department of Defense (DoD)-specific regulations. The intended user community will consist of water/wastewater treatment plant operators, compliance officers, supervisors and other responsible parties at DoD military bases and installations.

Air Quality Management (AQM)

The Air Quality Management (AQM) module will track air emissions, recordkeeping, and reporting data in compliance with the Clean Air Act. At a minimum, it will track air emission inventories,

Title V and other permitting; New Source Reviews; National Emissions Standards for Hazardous Air Pollutants (NESHAPs); and ozone depleting substances (ODS).

Tank Management
The Tank Management module will track compliance and other data for underground and above ground storage tanks, including historical data and information related to the physical characteristics, compliance status, testing of tanks.

Solid Waste Annual Reporting System (SWARS)
The Solid Waste Annual Reporting System (SWARS) tracks collection, disposal, recycling and cost data and maintains historical records. Graphical trend analysis assists in proactive compliance with Corporate Measures of Merit

Pest Tracking Management
The Intgegrated Pest Management Information System (IPMIS) is used by installation pest managers to track information related to the application of pesticides. The module maintains historical records and creates reports on applicator certification information, pesticide pounds of active ingredient, and pesticide management tasks.

Toxic Substances Management
The Toxic Substances Management System module will be used to track substances under the Toxic Substance Control Act such as asbestos, lead based paint (LBP) and radon. This module will assist installation managers in identifying potential hazards.

The first increment of EIM will be released to the Military Services and Defense Agencies beginning in the 2nd Quarter (FY) 1999. The first increment of EIM will include Hazardous Substance Management, Water Quality Management, limited Air Quality Management, and Tank Management.

GUIDANCE TO EVALUATE THE PLANNING AND IMPLEMENTAION OF A POLLUTION PREVENTION (P2) PROGRAM

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ABSTRACT: Too often, Pollution Prevention (P2) Coordinators are given the task to develop, implement, and manage the P2 Program with little or no guidance, support, or training. Consequently, it may be difficult for them to determine the actual status of their P2 Program with regard to meeting the 50% Hazardous Waste (HW) reduction goal by December 1999. This is especially evident if a Plan of Action and Milestones (POA&M) has not been created and adhered. Official guidance documents are available but may not be specific enough, may be too confusing, or possibly overlap and conflict with other guidance. In this study, a number of guidance documents were examined. The result was the development of a series of simplified and comprehensive checklists to evaluate a P2 Program. Specifically, these checklists can serve to evaluate a P2 Plan, develop a POA&M for P2 Program implementation, and measure the progress of a P2 Program. More importantly, these checklists can be used to avoid costly and time-consuming barriers to implementing the P2 program and its initiatives. The results of this study can also aid the P2 Coordinator in identifying the resources and commitment that will be required to implement P2 initiatives. A natural development generated from this study is to automate these checklists, and eventually include a cost/benefit module designed specifically for the P2 Program to better assess the desirability and feasibility of individual P2 initiatives.

INTRODUCTION

The Pollution Prevention Act (PPA) of 1990 was enacted to reduce the generation of hazardous wastes (HW) and consequently, decrease the toxic impact of their discharge in the environment. As a result, Executive Order (EO) 12856, subsequently signed on 3 August 1993, directed each federal agency to develop and implement a pollution prevention (P2) strategy to reduce HW discharges by 50% before 31 December 1999. These agencies were directed to conduct facility and acquisition activities so that the quantity of toxic chemicals (TC) entering any waste stream would be reduced as "expeditiously as possible to the maximum extent practicable".
As a result of EO 12856, a number of P2 guidance documents were developed for each federal agency, commonly from various levels within each federal agency. Initially, these guidance documents, some poorly written and in conflict, were confusing. Revised guidance documents were more useful, took more of a straightforward approach, and provided a great deal of information. Yet, the implementation of P2 programs has been met with varying success.

A recent study (1) revealed that Pollution Prevention (P2) Programs at some government installations have encountered various implementation problems. This study identified a number of causes that contributed to these problems. For instance, the P2 Program was not sufficiently developed or implemented. Inadequate or unused P2 Plans, the wrong approach to CHRIMP implementation, and resistance to change were a few of the causes cited. In some cases, P2 management and resources were ineffective, while deficient P2 guidance was cited for other cases.

Although most federal activities did not formally begin their P2 Program until the end of 1995, their programs have had the opportunity to mature. However, P2 Coordinators are still encountering problems; their P2 Programs can generally still be improved. Additionally, the question, Can the P2 Program be sustained after the year 2000?, looms on the horizon.

This study revisits P2 guidance and culminates in a compilation of concise and direct checklists on P2 Program planning, P2 Plan suitability, and P2 Program implementation to be used as tools to accomplish the following: 1) serve as a guide for performing an evaluation of the program's status and progress, 2) provide comprehensive guidance to be used as a trouble-shooting tool, 3) use as a guide for special P2 projects or revising the P2 Plan, 4) stimulate an anemic P2 program by generating new ideas and opportunities for HW reduction, and 5) use to make beneficial adjustments to the P2 Program strategy. The overall objective of this study is to step back and look at the P2 Program holistically. An effort to better understand the P2 Program at this time will help ensure sustainability in striving toward the P2 goal and beyond. This program is intended to become part of the command culture, and these efforts should continue to make that possible.

METHODOLOGY

To provide a checklist that would be considered easy to use, yet comprehensive, a number of P2 guidance resources were examined (2-8). Inconsistencies between the guidance documents were resolved by simplifying and organizing them. Also, the vast amount of information provided by these guidance documents was assimilated and condensed. The result was the generation of three checklists - organized summaries of the P2 Program – that are designed for ease of use. However, it should be noted that these checklists are unofficial, and should only be used as an internal guide.

Evaluating Pollution Prevention (P2) Implementation. The purpose of this checklist (Table 3) is to identify the required resources to ensure the implementation of an effective P2 Program. Again, key aspects include: management commitment, designation of the right P2 Coordinator, outlined responsibilities, adequate resources, training, good communication, and accountability. The P2 Implementation Committee must be interdepartmental, bringing together the functional groups having authority over HM management and specific-processes. The committee is established to advise the CO on policies and procedures designed to implement the P2 Program. Suggested functions include: integrate P2 planning into a coordinated P2 Program, periodically review operations involving HM to identify P2 opportunities, approval authority for methods and procedures for the P2 Program, establish a P2 awareness training program, propose annual reduction goals, monitor the progress of specific-process improvements, and make recommendations to improve P2 effectiveness. The HW Management Plans and the emergency procedures in the Spill Contingency Plans must be referenced in, or incorporated into the P2 Plan. An oversight of the P2 Program will be conducted by performing an annual review to evaluate the objectives and the effectiveness of the P2 Plan, and to recommend changes and improvements. Record keeping and reporting includes HM inventory control documents and records for HAZCOM and RCRA training. More importantly, a formalized and dynamic P2 instruction establishing actions and responsibilities must continually be promulgated.

CONCLUSIONS

For federal activities, the P2 Program is chronologically halfway to 31 December 1999, the deadline to accomplish the goal of a 50% reduction of HW generation. It is a good time for each activity to evaluate their P2 Program, what it has accomplished and what it has left to accomplish. With regard to sustainability, there appears to be a need to jumpstart the P2 Program and ensure that this program is a continuing process, even beyond the goal deadline. When a program is stagnated, a return to basics can generate ideas that can prove beneficial to the resurgence and continuity of the program. The checklists presented in this study provide basic guidance for a fundamental P2 Program. Their purpose is to serve as tools to assist P2 Coordinators who desire to evaluate their P2 Program. One possible way this can be accomplished is to grade each checklist item with a weighted scale. This could be automated and combined with a cost/benefit module to provide better information for P2 management decisions. These checklists can also be useful when proposing and implementing a new P2 initiative. They are bullet-formatted guides to the whole P2 process.

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Table 1. Evaluating P2 Program Planning Obtain Guidance The P2 Team Preliminary Planning Document Review Set P2 Goals Scheduling; POA&M Developing the P2 Plan Establishing Administrative and Management Elements Awareness Training, HMC&M, Implementation, Annual Update, etc. Command Commitment Data Collection and Site Assessment Collect Process-Specific Data Document Existing Pollution Prevention

Measures Site Assessment Identify and Analyze Reduction Opportunities Prioritize Reduction Opportunities Preparing the Assessment Report Identify P2 Options Evaluate P2 Options Technical Evaluation Economic Evaluation Rank Pollution Prevention Options Make Recommendations Prepare the P2 Plan

Table 2. Evaluating the P2 Plan Purpose Policy Applicability and Scope Applicability Scope Description of Shore Activity Mission Statement Geographical Designator Nature of Operations Current Status of Regulatory Compliance Summary of Current P2 Practices and Assigned Responsibilities Administrative and Management Elements Assignment of Actions and Organization of Administrative Effort Identifying P2 Training Source Reduction, Reuse, and Recycling Incentive Programs Procedures for Exchange of Information Update and Refinement of Plan Procedures of Measuring Hazardous Material Management Procedures Planned Process-Specific Improvements Identify Develop Options Summarize and Rank Recommended Actions Specific State and Local P2 Requirements Results of the Process-Specific Improvement Evaluation Priorities Potential barriers to the P2 Plan Other Requirements Legislation Other Required Environmental Management Plans Local Pollution Prevention Requirements Information Transfer Requirements Commanding Officer's Certification of Accuracy and Completeness

Table 3. Evaluating P2 Implementation P2 Program Development P2 Program Elements P2 Implementation Committee Membership Chairperson CO or designee Other Members: Environmental Division Occupational Safety and Health Supply (Receiving and Shipping) Contracts (Material Procurement) Operations (Production, Mission, etc) Public work/facilities Technical Specialist (Chemist) Production Planning/Engineering Quality Assurance Emergency Response Suggested Functions of the P2 Committee HM Management HM Inventory MSDSs Labeled HM and HW Containers The Safe Use of HM HM Acquisition Controls and AULs Safe Receiving, Distribution, Issuing, and Shipping of HM Storage of HM Specific-Process Improvements Complete Action Monitor Effectiveness Identify Addition P2 Opportunities Management of HW Emergency Response Planning Oversight of P2 Activities Recordkeeping and Reporting

Overview of the AFMC Environmental, Safety, and Health (ESH) Cost Analysis Guide

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The AFMC Environmental, Safety, and Health Cost Analysis Guide was prepared as an AFMC discretionary document for use by members of the Environmental, Safety, and Health (ESH), Engineering, and Financial Management Communities that need to identify, treat or use ESH costs in system decision making. Ms. Mary Helen Alverio of the Air Force Space and Missile Systems Center (SMC) served as the Government project director. Mr. Gerald B. Kos served as the program manager for the development of the Guide for the Air Force Space and Missile Systems Center. The web site for the Guide was not available prior to publication of this document, however, it will be available at the conference. The point of contact for questions, comments and suggestions regarding this Guide should be directed to SMC/FMC Ms. Mary Helen Alverio at 310-363-2822. Faxes may be sent to 310-363-3518. Ms. Alverio may also be reached at her Internet address, mary.alverio@losangeles.af.mil. In the event that Ms. Alverio may not be reached, contact Mr. Gerald Kos at 310-615-4552. His Internet address is HYPERLINK mailto:kosgb@aol.com kosgb@aol.com .

This Guide seeks to bring together in one document all ESH cost estimating related requirements and processes. Figure 1, on the following page, shows how the ESH Cost Analysis Guide brings together the ESH related requirements in the ESH specialties, Systems Engineering principles, and Financial Management policies and procedures. The right side of the figure shows some applications of the Guide that support sound decision-making processes for the Single Manager (SM).

The Guide has two primary parts: ESH information and ESH Cost Estimating. Part One, ESH Information, consists of two sections. Section one provides an overview of ESH management information that a cost analyst will need for ESH cost estimating efforts. This involves providing the background history and defining ESH Management and ESH Cost. Section two informs the cost analyst of the major ESH activities, by phase, over the life cycle of a weapon system.

Part Two, ESH Cost Estimating, is also broken into two sections. Section one discusses the basic cost estimating concepts that include ESH cost estimating requirements, objectives, and activities. Section two reviews the cost estimating common processes and their application to ESH cost estimating.

The appendices of this document furnish reference material that is very helpful to personnel recently introduced to ESH cost estimating. Appendices A and B provide the cost analyst samples and examples of program cost estimates (PCEs) and trade studies that incorporate ESH costs within the cost estimating common process illustrated in Part Two. PCE examples are provided for a Delta Launch Vehicle, Fighter Aircraft, Global Positioning System (GPS) space vehicle, Radar Program, and Satellite Communications Terminal. Trade study examples are provided for a Hush House Fire Suppression System, Coating Removal Processes for Helicopter Remanufacture, Canopy Replacement for the F-15E, Replacing Cadmium Plating with IVD

Aluminum Coating for Corrosion protection, and CFC-114 Refrigerant Replacement Study. Other key information provided in the appendices includes a glossary of ESH terms and definitions, a summary of ESH related laws and regulations and their impact to the single manager, functional support organizations for the cost analyst, an enhanced ESH Work Breakdown Structure (WBS), cost identifying questions by topic and organization/function, potential ESH cost estimating tools, and a discussion about the potential use of Activity-Based Costing (ABC) / Activity-Based Management (ABM) with ESH cost estimating.

Session XXIX
Anti-Icing/De-Icing

Session Chairpersons:

Mr. Jay Shah, HQ USAF/ILEVQC
Captain Greg Durand, USAF, HQ USAF/ILEVQ

Session XXX
Compliance Through P^2 Initiatives

Session Chairpersons:

Mr. Robert Hoye, International Technology
Mr. Rick Gardner, NFESC

AIMM to SCORE – Achieving Navy Environmental Excellence

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Background

While the term "pollution prevention" is relatively new (being officially defined in the Pollution Prevention Act of 1990), the concept of Federal agencies being sensitive to environmental issues is not. The passage of the National Environmental Policy Act (NEPA) in 1969 required agencies to consider environmental impacts resulting from their actions. The 1984 amendments to the Resource Conservation and Recovery Act, known as the Hazardous and Solid Waste Amendments or HSWA, began to define the concept of hazard reduction. HSWA initiated the requirement to document hazardous waste minimization efforts on hazardous waste manifests. This prompted all waste generating entities to consider what they were doing that could be changed to reduce waste production. This was the starting point of the first generation of pollution prevention (P2) in the Navy.

The first generation of Navy P2 reflected the belief that P2 was a good thing to do. Navy activities were encouraged to practice hazardous waste minimization (HAZMIN) to meet the HSWA requirements to and save money on hazardous waste disposal. Programmatically, the Navy focused on reduction in hazardous materials (HAZMAT) use through technology and reduction in disposal of unused HAZMAT through centralized HAZMAT management. In 1985, the Naval Energy and Environmental Support Activity and the Naval Civil Engineering Laboratory (now the Naval Facilities Engineering Service Center) began an effort to review hazardous waste generation records, determine major wastestreams, and research what could be done to reduce or eliminate these wastestreams. In 1986, the Navy developed a matrix of waste generating processes, potential reduction technologies and goals for waste reduction. Major waste streams identified included bilge water, paints, solvents, paint stripping waste, and plating/metal finishing wastes. Initial waste minimization efforts concentrated in these areas. This study also identified areas where no currently available commercial technologies existed and where research and development efforts were required.

The Consolidated Hazardous Material Reutilization and Inventory Management Program (CHRIMP) was created at Naval Air Station, Point Mugu, CA in the late 1980s. The program controls and tracks every aspect of the identification, receipt, issue and costs associated with all HAZMMAT including both new and reutilized HAZMAT. CHRIMP enables HAZMIN Centers to requisition and issue the right quantity of HAZMAT on a "just-in-time" basis, reissue partially used containers, and record the quantity of all HAZMAT by chemical present on an installation.

Based on the success of CHRIMP, the Naval Supply Systems Command was directed to implement it across the Navy, both afloat and ashore. Progress in the Navy HAZMIN program was evidenced by the better than 50% reduction in waste reported from 1987 to 1993.

The second generation of Navy P2 began in August 1993 when President Clinton signed Executive Order 12856 which directed federal agencies to comply with the provisions of the Pollution Prevention Act of 1990 and the Emergency Planning and Community Right to Know Act (EPCRA). Executive Order 12873, signed in October 1993, further committed federal agencies to P2 by setting requirements for cost effective waste prevention, recycling and procurement of environmentally preferable products. Taken together, these executive orders created "compliance requirements" which the Navy then set out to meet.

The P2 program Navy created to address the executive order requirements is reflected in its acronym, AIMM. AIMM stands for Assess, Implement, Manage and Measure. The program seeks to assess P2 opportunities through P2 planning and supported by tools such as the model P2 plans, P2 Planning Standard Operating Procedure, P2 Opportunities Handbook, Tri-Service P2 Technical Library, Navy Environmental Leadership Program, P2 Afloat Program and P2 Equipment Pre-production Demonstration/Evaluation. Based on sound evaluation, P2 opportunities are implemented through the annual Baseline Assessment process, P2 Equipment Program, and ODS Conversion Program. Materials and waste streams which cannot be reduced or eliminated, are carefully managed utilizing programs including Consolidated Hazardous Material Reutilization and Inventory Management Program (CHRIMP), the Hazardous Substances Management System (HSMS), the Navy Qualified Recycling Program (QRP), as well as regulatory permitting programs. Finally, progress is measured thorough reporting under the Emergency Planning and Community Right to Know Act and the DoD Measures of Merit. Efforts to integrate environment, safety and health (ESH) into Navy acquisition programs through initiatives such as the Joint Group on Acquisition Pollution Prevention (JGAPP) and establishment of ESH oriented Integrated Process Teams also support the AIMM philosophy.

The AIMM philosophy has served the Navy well. The DoD measures of merit show significant progress. From a CY94 baseline, we have reduced toxic releases by 51% as documented in our 1996 Toxic Release Inventory (TRI) reports. Navy hazardous waste disposal in 1997 was down 56% from the CY92 baseline. Solid waste disposal in 1997 was down 22% from the CY92 baseline and we diverted 36% of our 1997 solid waste stream to qualified recycling programs or composting efforts. The challenge faced by the Navy P2 program was how to take the AIMM philosophy, and utilize it to support our overall environmental quality program. The next step was to move to a third generation of P2 that is focused on moving the Navy forward.

Third Generation Navy Pollution Prevention

At the May 1997 Navy Pollution Prevention (P2) conference, there was significant discussion on the direction the Navy P2 community needed to go to meet future requirements. As a starting point, CNO(N45) laid out a vision for the program with some long and short-term goals and objectives. That vision reads:

"Support operational readiness by achieving cost effective full and sustained compliance and enhanced personnel safety through innovative, aggressive use of pollution prevention."

This vision has been very well received by Navy's P2 community. Over the past year, the CNO Pollution Prevention Branch, CNO(N451), has worked to focus the Navy P2 program to accomplish the accompanying goals and objectives. The results are the development of an overall environmental quality philosophy known as "AIMM to SCORE" and the Navy Environmental Quality Initiative (EQI) which is intended to focus the P2 program on supporting sustain compliance at lowest life cycle cost.

AIMM to SCORE

It has become very clear that it is counterproductive to view P2 and compliance as separate, often competing, pillars of the environmental program. A more useful approach is to view P2 as a tool to support sustained compliance at the lowest life cycle cost. Compliance is an end state. P2 is a means to that end. The net result is improved environmental quality.

Working together, CNO Environmental Compliance and P2 staff developed a philosophy for a Navy Environmental Quality (EQ) Program. We quickly agreed that what we were striving for could be summed up as "Navy Environmental Excellence". In trying to define what that means, we determined that there are two fundamental elements required. First, we must support the operational readiness of the United States Navy to perform its national security mission. Second, we must achieve and maintain sustained compliance. Both elements must be present. Operational readiness without sustained compliance cannot be maintained for long. Sustained compliance without operational readiness is not excellence for the United States Navy. Being good Navy employees, we immediately turned this vision into an acronym:

SUSTAINED COMPLIANCE + OPERATIONAL READINESS =
ENVIRONMENTAL EXCELLENCE (SCORE)

Our challenge is to use the outstanding success we have achieved to date with the AIMM program to SCORE big for the Navy. One of the tools we will use is the Navy Environmental Quality Initiative.

Navy's Environmental Quality Initiative

A key element in implementing the AIMM to SCORE philosophy is the Navy's Environmental Quality Initiative (EQI). The Navy EQI is a comprehensive initiative focused on maximizing the use of pollution prevention to achieve and maintain environmental compliance. The goal is "Sustained Compliance at Lowest Life Cycle Cost". Navy's EQI has four primary objectives:

1. Reduce the Life Cycle Cost of Navy's Environmental Quality Program

2. Achieve Sustained Environmental Compliance at Navy Activities
3. Reduce Generation of Pollutants at Navy Activities
4. Increase Use of P2 Alternatives to Environmental Compliance Requirements

In order to make AIMM to SCORE a reality, we need to think differently about the P2 program and how it supports Navy's national security mission. The primary legal drivers for the P2 program, Executive Orders 12856 and 12873, require federal agencies to do P2 planning, practice source reduction, increase recycling, implement cost effective waste reduction and make good life cycle cost decisions. Current Navy P2 planning is focused on meeting these requirements. In many cases actions to comply with the executive orders support compliance with statutory and regulatory requirements, but such compliance has not been a major program driver. There appears to be little or no meaningful interaction between P2 and compliance personnel at many Navy activities. In the short term, the EQI will help us to focus on supporting statutory and regulatory compliance. In the longer term, the EQI will support a transition from P2 planning to more comprehensive environmental quality planning with the focus on lowest life cycle cost, sustainable compliance. In order for EQI to succeed, compliance and P2 personnel must work together as an integrated unit with a common goal.

During the May 1997 Navy P2 Conference, there was an excellent discussion on activity P2 plans. Some activities were using them as an integral part of their day to day operations, and others have put their plan on the shelf. Some activities view the plans as essential tools to support their environmental programs, have shared the plans with their compliance and maintenance counterparts, and have implemented numerous successful opportunities. Other activities viewed completion of the plan as compliance with a CNO directive. These activities do not use the plans as tools to support their environmental programs, have not shared the plan with anyone outside the activity P2 program and have met with little success in the implementation of opportunities. The majority of activities seem to fall somewhere in between.

We are concerned about investing scarce Navy resources in additional extensive (and expensive) plans that may not be any more effectively utilized that some of the current activity P2 plans. We want, however, to move forward with environmental quality planning at Navy activities. Environmental quality planning should not be an onerous requirement from CNO that has to be completed before getting on with the real work. Our challenge is to enlist everyone in the Navy to use P2 in environmental quality planning for effective, efficient mission accomplishment.

Rather than jumping directly into activity environmental quality plans, the EQI supports a series of interim steps to gradually transition from P2 plans to more comprehensive environmental quality plans. We intend to make the best possible use of the significant assets we already have such as the activity P2 plans, the PPEP, and the P2 Technical Library to support our vision. For subsequent P2 plan updates, we will encourage and work to support activity efforts to broaden their plan's focus to integrate sustained compliance through source reduction, reduced toxic releases, and minimum life cycle cost. The Naval Facilities Engineering Service Center (NFESC) has begun work to assist in this phase of the EQI by gathering and reviewing all of the current activity P2 plans. NFESC is developing lessons learned and documenting implemented

successes from review of these plans. This information will be provided to Navy major claimants and activities to support activity plan updates.

NFESC has also been tasked to identify specific P2 for Compliance opportunities and package them for distribution throughout the Navy. General implementation practices that help target specific compliance requirements and identified P2 alternatives are being developed. Opportunities common to particular types of activities or operations will be identified and support information will be targeted to that audience. The goal for this effort is to highlight alternatives that support multiple compliance requirements, source reduction and health/safety enhancement.

FY98, FY99 and FY00 Baseline Assessment Data is being reviewed by NFESC to identify and prioritize compliance requirements for which P2 solutions will reduce the life cycle cost of compliance. Beginning with Program Review 2001(PR01), guidance on using P2 to support compliance will be inserted into the compliance sections of the Navy Environmental Requirements Cookbook to increase visibility and ensure P2 alternatives are considered and incorporated up front. For POM 00, we plan to insert specific P2 for compliance line items into the cookbook. This will improve and support the ability of Navy activities to identify and fund P2 alternatives to compliance requirements.

Another significant element of the EQI is the Navy's new Environmental Quality Assessment (EQA), a revamped Environmental Compliance Evaluation. The EQA has a goal of continuous improvement at the command level by providing continuous auditing and feedback. This is achieved with an Internal Assessment Plan that provides for data collection, evaluation of compliance posture, root cause analysis, management review, and identification of pollution prevention opportunities on an ongoing basis. With this feedback loop, P2 becomes everyone's business.

Over the long term, our goal is to institutionalize integrated environmental quality planning. This will support operational readiness by targeting source reduction efforts to reduce current and future regulatory impacts on Navy operations, and their associated cost to the fleet. The net result will be sustained compliance at the lowest life cycle cost. That is the target for which we hope the entire Navy will AIMM to SCORE.

Air Combat Command Approach to Funding Compliance Through Pollution Prevention

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Introduction. The Air Force's "P2 first" approach to solving compliance needs has dramatically shifted the way Pollution Prevention projects are identified and programmed. No longer is the program driven by goals, but by correcting and preventing non-compliance. A 12 Sep 97 AF Environmental Division memo states, "AF policy is to use cost effective P2 projects and activities to correct and prevent environmental non-compliance." Several more Air Force policy letters emphasizing its commitment to shifting funds from Environmental Compliance (EC) to P2 solidified the policy shift. Air Combat Command (ACC) has supplemented Air Force policy by releasing "ACC Pollution Prevention Funding Guidance" in June of 1998. This document instructs ACC bases on how to effectively identify, justify, and program valid P2 projects to implement the new AF policy. The purpose of this paper is to review the fundamental change in P2 management and outline how ACC had adjusted its strategy to meet this challenge.

Background. Since its inception, the Air Force's EC program has enjoyed tremendous success. By the end of 1997, the AF had fourteen open enforcement actions for non-compliance and ACC had brought open enforcement actions to zero. This success was achieved with a two-pronged approach: strong emphasis on complying with environmental laws and a financial commitment to correct non-compliant conditions. Similarly, the AF's P2 program had successfully reduced waste streams. DoD goals for solid and hazardous waste reduction have been achieved before the target dates, and the AF has instituted the hazardous material pharmacy (Hazmart) concept for cradle to grave management of hazardous materials.

Unfortunately, the success of the EC and P2 programs has been separate and independent. By instituting "environmental quality (EQ)," the AF hopes to combine the success of these two programs to achieve a common end -- environmental compliance. This common goal can be seen as not only compliance, but also, through P2, eliminating the need to comply.

The EC program has traditionally found end-of-pipe solutions to solve compliance requirements. This approach side-stepped the AF's environmental management hierarchy (source reduction, recycling/reuse, treatment, disposal). The typical end-of-pipe approach (Fig. 1) involves obtaining permits and/or conducting recurring sampling, monitoring, and reporting. In addition to generating long-term operations and services costs, this approach also involves several "compliance points," or activities that are susceptible to enforcement action. A P2 approach (Fig. 1), which involves source elimination, recycling, re-use, or treatment may also be available, which eliminates the need for permits and associated sampling and reporting. The compliance point could be eliminated, along with the potential for enforcement. The P2 approach would

then be the means for attaining compliance -- this is the essential core of the Air Force's "Compliance Through Pollution Prevention" program.

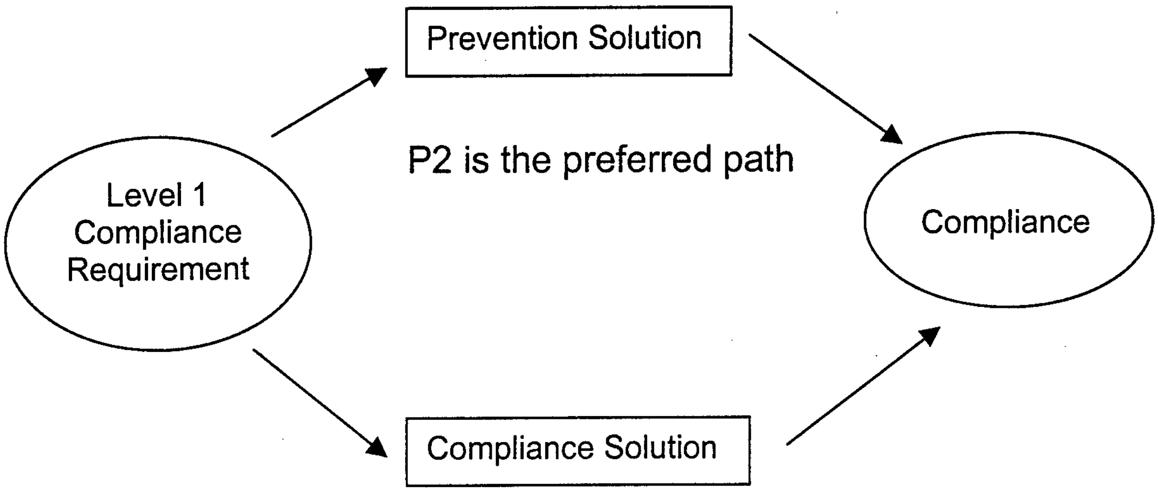
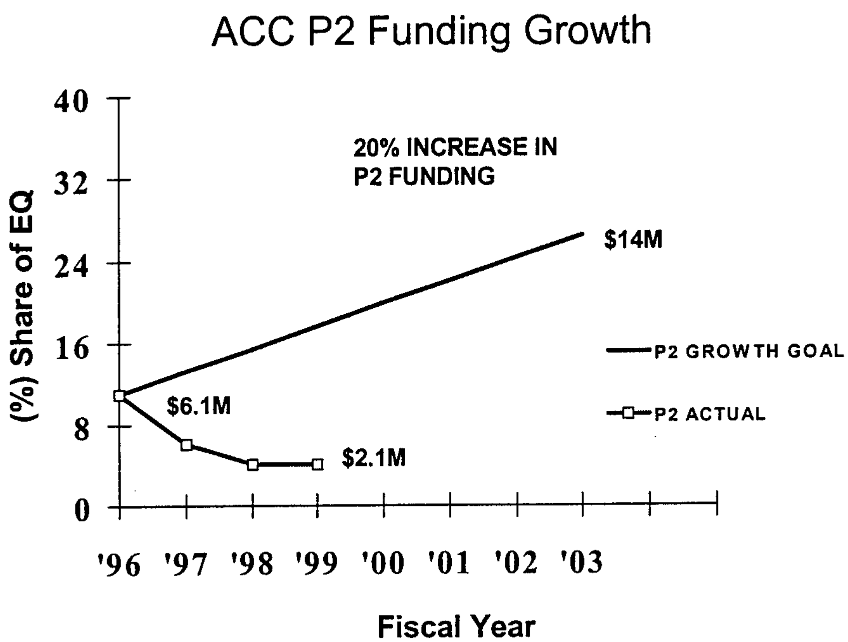


Figure 1. Two Approaches to Achieve Compliance

The Air Force Civil Engineer backed up the commitment to Compliance Through Pollution Prevention (CTP2) by agreeing to increase by 20% P2's share of the EQ budget based on a FY96 baseline by FY03 (excluding manpower and training costs). ACC's P2 budget in FY96 was \$6.17M, 11% of the EQ budget. In FY03 P2 will need to have 31% of the EQ budget, which will be approximately \$17.4M. The figure below shows the share of the ACC EQ budget that the P2 program has received over the last few years. Traditional P2 projects are being funded at lower levels. Beginning in FY00, funds will begin to migrate to the new CTP2 program.



AF Funding Guidance. The 12 Sep 97, AF Environmental Division memo that released new funding guidance for the P2 program, included an updated set of DoD EQ Class definitions. Previously referred to in the Air Force as "Levels," these class definitions drive our investment strategy. In general, Class I requirements are those which correct an environmental problem where we are not complying with mandates from the federal, state, or local authority, or investments needed in the program year to avoid being out of compliance.

Previous to this funding guidance, P2 and EC had separate class definitions. The distinction is now gone. Projects that qualified as "P2 Level 1" in the past must now compete for funding on the same playing field as EC Class I requirements. This means that it will be more difficult to obtain funding for previously "goal driven" P2 requirements such as recycling, composting, and hazardous material management.

The new emphasis in CTP2 and the change in funding class definitions present a challenge to P2 program managers. Air Force Major Commands must now find a way to increase the P2 share of the EQ budget by 20% and, at the same time, only fund valid Class I requirements.

ACC Funding Guidance. In order to meet the challenge of beefing up the P2 Class I program, ACC developed P2 Funding Guidance to give its bases instructions on how to increase and support their programs in FY00-05. The document streamlines and standardizes the Class 0 (Operations and Services) budget and gives direction on programming valid Class I and Class II projects.

Recurring Requirements. Recurring Operation and Services, requirements are categorized into five standard line items: Civilian Pay, Office Supplies, Hazmart Supplies/Equipment, Training/TDY, and QRP Supplies. Each line item has an established amount for each base to program or sets a maximum limit bases cannot exceed. This standardized program lets the bases

know up front what ACC will validate, so they can effectively submit a program that will be funded. The bases no longer have to play a guessing game trying to program the right combination of recurring projects to win the P2 jackpot. The standard list also allows ACC to distribute P2 funds fairly. No one base can corner the market on Class 0 projects. Other (non-standard) recurring projects may be programmed, but must be well justified and will be approved on a case-by-case basis.

Non-Recurring Requirements. Instructions for programming non-recurring requirements consist of a 3-step process of project identification, justification, and programming.

Identifying Projects. The first step in building a solid program is finding the right projects to program. Bases are encouraged to:

- Go through the valid non-recurring projects listed in the 12 Sep 97 HQ AF/ILEV letter for solutions to compliance problems.
- Look through the base EC program and talk to base compliance experts. With the new funding shift, P2 solutions can be found and funded from traditional compliance projects.
- Examine the findings from the last external and internal ECAMPs.
- Review the base's last P2 Opportunity Assessment (OA) for valid projects.
- Check out the Model Shop Reports developed by AFCEE (see PRO-ACT Cross Talk, Oct 97). Six Model Shop Reports have been developed from P2 OAs for some of the largest users of hazardous material and biggest producers of HW. These reports are contained in the Aug 97 Tri-Service Pollution Prevention Resource CD. They are also available for downloading on the AFCEE home page (www.afcee.brooks.af.mil).
- Talk to the customers; use the P2 Cross Functional Team (CFT) as a means to beat the bushes for valid P2 compliance-driven projects. Target the biggest compliance problem areas for the best P2 solutions.

Justifying Projects. If the project cannot be justified as a valid O&S requirement or as a Class I project, it will probably not be funded. ACC is now using a scoring system to prioritize and fund non-recurring projects (Table 1). Bases are encouraged to use the same scoring criteria to help justify and prioritize projects. Projects will be scored using the following criteria:

- Regulatory Driver – What law drives this project (i.e. CAA, RCRA, CWA)? Will it reduce or prevent the base from receiving an enforcement action?
- Regulatory Agreement – Is there an agreement with the regulator to perform this action?
- Payback – How soon will the project pay for itself? (if applicable)
- DoD/AF goal – Does it help meet an AF or DoD goal?

Table 1. ACC Funding Matrix

Regulatory Driver	Out of Compliance	Prevents potential non-compliant situation	Reduces compliance vulnerability	Goal-driven only
	10	7	3	0
Regulatory Agreement		Yes	No	
		5	0	
Payback	2 years or less	5 years or less	Over 5 years **or** payback evident but not shown	Negligible payback
	5	3	1	0
AF, DoD goal		Helps meet goal	Doesn't help with goal	
		3	0	

The funding matrix is used to assign each project a score from 0 to 23. Projects will be prioritized for funding based on this score. The above items must each be addressed in the narrative block of the WIMS-ES A-106 report, so projects can be accurately scored.

The most important of the criteria to justify is the regulatory driver. This portion of the narrative must explain what makes the project Class I. P2 projects can be justified as Class I if they solve a compliance problem, are included in a permit, close an ECAMP finding, or prevent recurring compliance violations. The base legal office and compliance program managers can help justify the funding class of P2 projects. Examples of Class I justifications for typical P2 projects are:

- Aqueous Parts Washer - CAA Title V permit requires parts washer by 1 Sep 98.
- Washrack Recycler - Wash water recycler stops unpermitted discharge of metals in violation of CWA.
- Backflow Prevention Devices - Base water supply system violates SDWA; requires backflow prevention devices.
- Vapor Recovery System - Reduces HAPs to prevent violations of NESHAP limits.
- Oil Water Separator Elimination - Eliminates recurring discharges of ______ in violation of CWA.

Programming Projects. The A-106 module on the Work Information Management System – Environmental Subsystem (WIMS-ES) is the required mechanism to forward requirements and justification to ACC and the Air Staff for validation and funding. Before a Pollution Prevention project can be validated and funded, it must be submitted in A-106.

Transferring Projects from EC. Projects cannot be programmed in both the EC and P2 programs. Pollution Prevention solutions are to be used as the first choice for solving compliance problems and, therefore, bases should program compliance projects within the P2 program first, if they have a P2 solution. When a project is moved from the EC to P2 program within A-106, the project's PEC and narrative must be updated.

Suggested Projects. The new funding guidance allows program managers to look places they haven't looked in the past for P2 projects. Below are examples of some valid P2 compliance-driven projects and project areas, organized by media. (These are simply examples

of valid projects and not an exhaustive list; even valid projects must have Class I justification for funding.)

- Clean Air Act
  - → Low VOC paint equipment or other VOC-reduction initiatives
  - → Projects that reduce emissions below Title V or NESHAPs
- Clean Water Act
  - → Projects that eliminate NPDES permits
  - → Water pretreatment projects
  - → Oil-water separator (OWS) elimination and floor drain closing
  - → Projects that tie processes/septic systems to the sanitary sewer
  - → Inflow/infiltration study/repair
  - → Deicing vacuum trucks
- Safe Drinking Water Act
  - → Backflow prevention projects
  - → Wellhead Protection
- RCRA – Hazardous Waste
  - → Parts cleaning systems
  - → Hazardous waste minimization equipment
  - → Part B permit elimination
  - → Bullet traps for small arms ranges to capture lead
  - → Aquatic harvesters or other equipment to reduce the use of herbicides/pesticides
- Underground Storage Tanks
  - → Leak detection/corrosion protection or elimination of USTs
  - → AST secondary containment (state requirements)
- Focused Opportunity Assessments
  - → By media (air, storm water, drinking water, etc.)
  - → By process/function
- Design of valid P2 projects

Conclusion. The new Compliance Through Pollution Prevention policy shift in the Air Force environmental program has provided an effective way to solve and prevent compliance problems through P2 solutions. The ACC Pollution Prevention Funding Guidance provides implementation instructions for the new policy. The guidance standardizes ACC's P2 program and instructs bases to identify, justify, and program valid projects to grow the P2 program. The new policy and guidance will steer the Air Force toward cost-effective and practical solutions to compliance problems over the next several years.

References:

1. HQ USAF/ILEV letter, 12 Sep 97, Pollution Prevention Funding Guidance.
2. HQ USAF/ILE letter, 20 Nov 97, Pollution Prevention to Achieve Compliance.
3. HQ USAF/ILE letter, 28 Jan 98, Transferring Funds from Environmental Compliance to Pollution Prevention.
4. HQ USAF/IL letter, 20 Apr 98, Environmental Compliance Through Pollution Prevention.
5. HQ ACC/CEV letter, June 98, ACC Pollution Prevention Funding Guidance.

Pollution Prevention at Fort Carson
By Accident or Design?

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Fort Carson is a major U.S. Army Forces Command installation located south of Colorado Springs, Colorado. The Installation is one of the largest in the Army, covering some 367,000 acres. It is the home of more than 15,000 active-duty military personnel and has more than 4,000 tactical vehicles. The Installation garrison consists primarily of the 3rd Armored Cavalry Regiment, the 3rd Brigade Combat Team of the 4th Infantry Division, the 43rd Area Support Group, and the 10th Special Forces Group (Airborne). In addition, tenant activities such as the Colorado National Guard, the Colorado Air National Guard, the Army Reserve, the Naval Reserves, Marine Reserves, Seabees and the Air Force Reserves train on Fort Carson.

The primary mission of Fort Carson is to train, mobilize, deploy and sustain combat-ready forces. Operational and training facilities and equipment supporting the mission include 24 motor pools, 67 training ranges, 56 training areas, Butts Army Airfield, 12 drop zones and the 235,896-acre Pinon Canyon Maneuver Site. The major industrial processes on Fort Carson are directly related to vehicle maintenance activities -- painting, routine maintenance of wheeled and tracked vehicles, engine rebuilding and aircraft maintenance. These processes consume large amounts of raw materials and tracking the attendant input and output streams is a formidable task.

Fort Carson recently won the Department of Defense (DOD) 1998 Pollution Prevention Award for a Non-Industrial Installation. The Installation has garnered numerous awards over the years for various environmental programs, but this was the first time the Fort Carson was recognized for its all-encompassing P2 program. The basic elements that went into the award submission package were parts of pre-existing environmental programs. Fort Carson already had incorporated elements of P2 into its existing program areas. What was needed to consolidate the program was to bring together the personnel from different programs in a team environment to assemble all the dispersed P2 initiatives.

Fort Carson's pollution prevention efforts are managed by the Directorate of Environmental Compliance and Management (DECAM). DECAM has taken a new approach to managing the Installation's Pollution Prevention (P2) Program. In September 1997, DECAM established a multidisciplinary P2 Team -- DECAM's first cross-functional team. Team members represent such diverse areas as environmental compliance, natural resources, the Hazardous Materials Control Center (HMCC or Hazmat Pharmacy), Recycling, Energy Conservation, Water and Waste Water, Supply and Procurement, Wildlife and other organizational areas. The reason for establishing this team was economics -- lack of available funding for the P2 manager position.

This problem has affected federal facilities since the effective date of Executive Order #12856 - November 3, 1993. The EO Compliance was an unfunded mandate -- the compliance costs had to come out of the existing total environmental pie. The required compliance is made more difficult due to the fact that there are no monetary penalty provisions associated with noncompliance with the EO.

To accomplish more with fewer resources, changes must be made to traditional methods of doing business. A team approach draws on the accumulated knowledge, skills and experience of multiple disciplines. Ultimately Fort Carson's DECAM expects good ideas and improved decisions, initiatives and solutions from the P2 Team. The mission of P2 is to reduce or eliminate pollution of land, air and water. Taking a proactive approach by advocating P2 initiatives is considered more appropriate for environmental compliance than being perpetually in a reactive mode. It is also much cheaper.

Fort Carson's pollution prevention mission is to "Perform all P2 management actions to proactively reduce or eliminate pollution of land, air and water for Fort Carson and the Pinon Canyon Maneuver Site for both long and short-term goals." In the last two years, the P2 program has provided continuous improvement in the basic program areas: hazardous waste and hazardous materials reduction, energy, recycling, staff assistance/inspections/training, water conservation, affirmative procurement and sustaining military training lands.

One of the most important initiatives in reducing hazardous waste and the amount of hazardous materials stored on the installation has been the Hazardous Material Control Center (HMCC) or Hazmat Pharmacy. The pharmacy management concept establishes a central location that controls purchasing, receiving, issue, storage, reuse and turn in/disposal of hazardous waste. Fort Carson is one of the beta test sites for the Army's Hazardous Substance Management System software.

The installation currently has about 60 percent of assigned units operating under the control of the HMCC for all hazardous products. As a direct result of the pharmacy, hazardous materials stored on post have been reduced from 1,716,850 pounds in 1994 to 765,600 pounds in 1996 -- a reduction of 55 percent. In its first year of operation (representing 20 percent of the installation hazardous materials), the pharmacy recovered and distributed for use more than $360,000 of excess products. It also extended the shelf life of 7,145 items at a cost saving of $260,000 and had a disposal cost avoidance of $560,000.

Fort Carson recycling efforts have been a long-standing, visible part of the P2 program. The post has its own recycling center that processes newspaper, cardboard, white paper, computer paper, plastics, bi-metal cans, aluminum cans and tab cards. A number of other items, including brass ammunition casings, steel and precious metals are recycled through the Defense Reutilization and Marketing Office. The installation recycles materials from base family housing, military units, civilian offices, the base commissary, the Air Force Space Command and the Federal Bureau of Prisons. One innovative program in Fort Carson recycling is the troop incentive program. Military units can collect recyclables and receive a portion of the recycling proceeds for their unit A total of 3,639,400 pounds of material were recycled in FY96. As a direct result of the recycling program, revenue of more than $300,000 was generated by sale of recyclable

washing was placed in the facility two and a half years ago and not a drop of water has been added to the system . The 15 inches of annual rainfall the post receives is adequate to make up for evaporation losses. Recently, grass carp were introduced into the basins of the CVWF to help control aquatic weeds which grow there. The CVWF provides water savings of 200 million gallons per year - a $200,000 saving. In it's nine years of operation, the CVWF has saved over 1.8 billion gallons of water.

2) The Fort Carson golf course uses approximately 90 million gallons a year of treated waste water for irrigation of 180 acres of greens, fairways and improved rough. This waste water irrigation has been ongoing since 1971. The waste water is pumped from the Fort Carson sewage treatment plant four miles to an aerated retention pond at the golf course. From there, it is applied to the irrigated acreage by a sprinkler system. This irrigation has saved more than 2 billion gallons of water since its inception.

3) Several management projects such as leak detection surveys, an Installation Design Guide (which requires use of low flow showerheads, toilets and urinals) and a feasibility study for expanding waste water irrigation have been used as planning tools for the water conservation program. Fort Carson is currently negotiating with its water supplier, the City of Colorado Springs, to provide nonpotable water for turf irrigation. Using nonpotable water will save the installation up to 50 percent in water costs for the irrigated areas. Turf irrigation in family housing has an automated control system using moisture probes to control application rates. Over 500 drought-tolerant trees were planted on Fort Carson to lower landscape demand for irrigation water.

These initiatives have produced measurable results. Water conservation methods save Fort Carson more than $330,000 per year in avoided water costs. The annual water usage savings for the golf course irrigation and the Central Vehicle Wash Facility alone are approximately 250 million gallons per year. In the past three years the innovative techniques and management practices at Fort Carson have produced a 12 percent reduction in water usage.

Fort Carson's positive procurement program helps meet pollution prevention goals. This program uses the GSA "Chasing the Arrow" program to identify energy-efficient office equipment (printers, fax machines, computers and monitors) and supplies with recycle content (copy paper, paper towels and toilet paper). Recycling of toner cartridges for fax and printers is mandatory. Energy efficient task lighting (compact fluorescents) is available through the DLA Green Lights Catalog.

Sustainability of military training lands is essential to Fort Carson's mission. Environmental stewardship is a primary goal of DECAM's management -- we must have a sustainable level of environmental quality in order to continue our military mission. To this end, the installation has done the following:

* Constructed more than 600 erosion control dams to control sediment runoff.
* Banksloped unstable areas to control erosion.
* Constructed 8,500 linear feet of terrace to control sediment runoff.
* Built 24 hardened crossings for armored vehicles in erosion-prone areas.
* Conducted extensive revegetation programs (more than 2,000 acres) for areas with maneuver damage.
* Performed dust abatement on approximately 100 miles of tank trails and training roads.
* Formed its own wildland fire team to control wildfires on the installation.

* Conducted basic research on sediment yield and erosion rates.
* Conducted wetland surveys and monitoring.

One initiative generated directly by the Pollution Prevention Team is a project using scrap vehicle track as rip rap for erosion control. This project reused almost two million pounds of scrap track headed for the landfill to armor a watercourse on the Installation to prevent erosion of a landfill cap.

Fort Carson is proud of its accomplishments in pollution prevention in the past two years. Not only is P2 cost-effective, but many of the projects implemented have made Fort Carson a safer place to work . This will help to preserve and enhance the natural beauty of the Pikes Peak region for years to come. The P2 program has demonstrated its effectiveness in reducing occupational and environmental hazards, improving operational efficiency and providing measurable cost avoidance benefits that support Fort Carson's military mission while improving environmental quality on the installation.

We understand our pollution prevention commitment to be a shared responsibility. Through strong leadership and a teamwork approach we have undertaken to increase awareness pollution prevention. Strong alliances and partnerships allow each member of the Fort Carson community to share in our commitment and success.